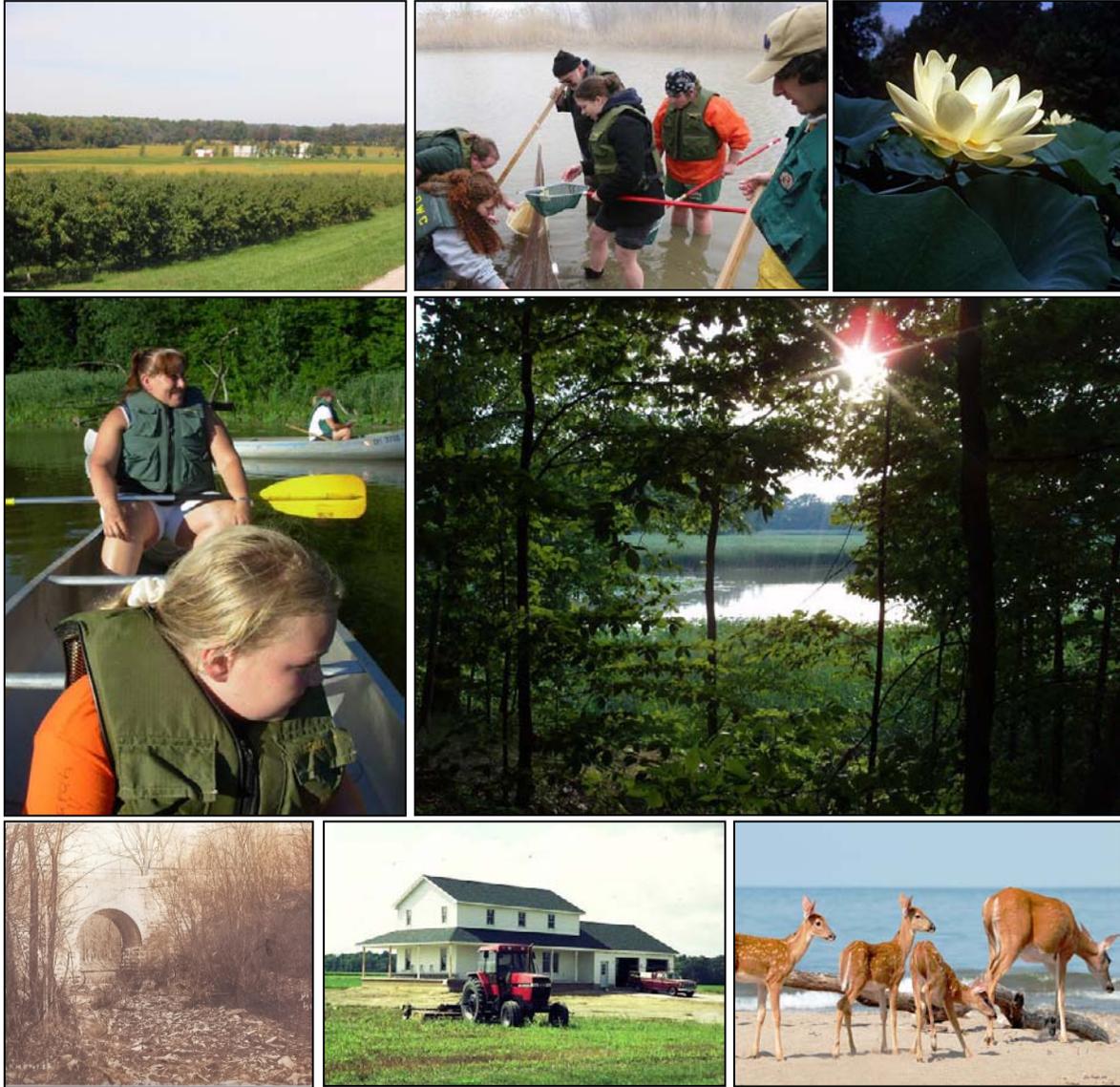
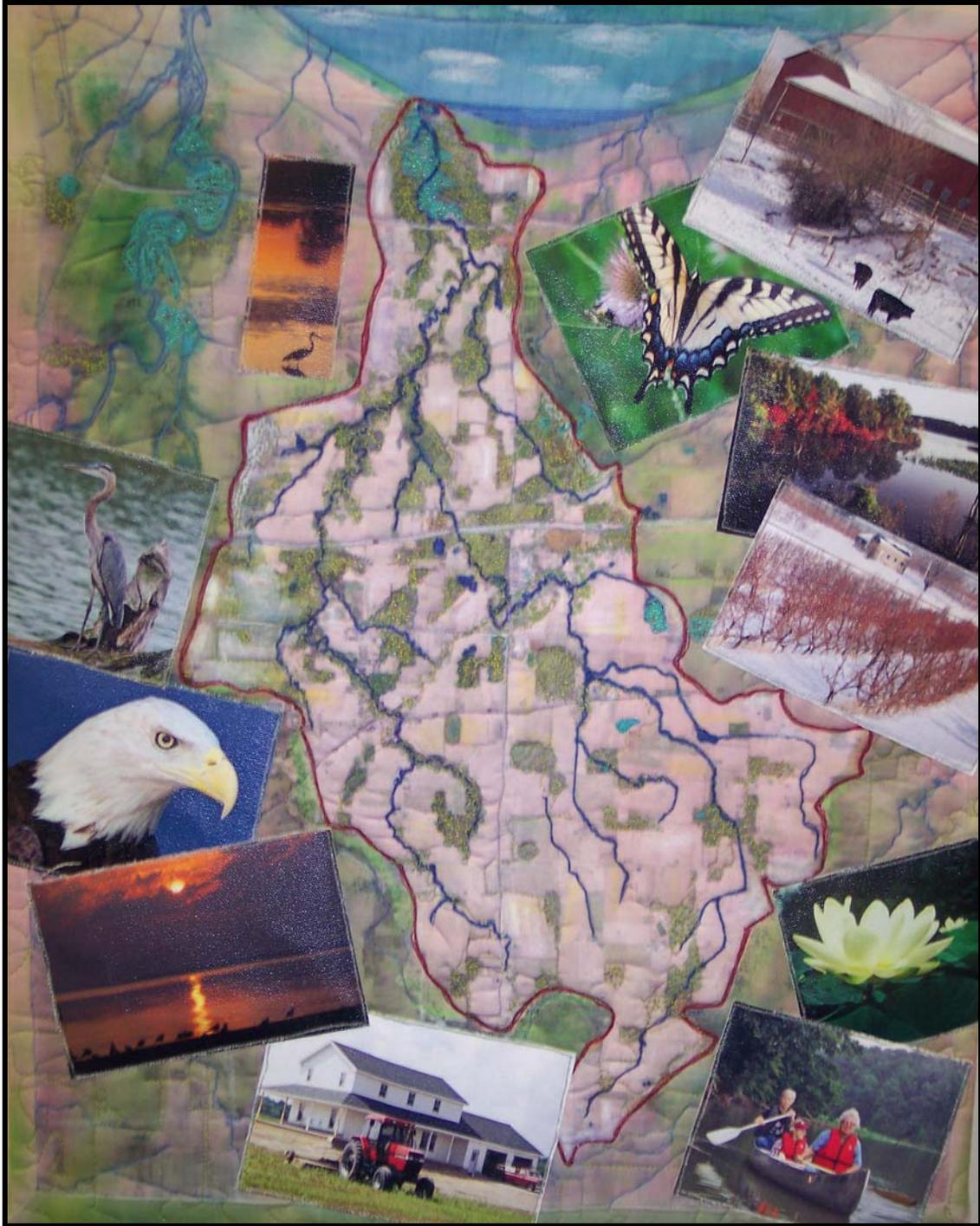


Old Woman Creek Watershed Action Plan



Firelands Coastal Tributaries Watershed Program
2009



Old Woman Creek Watershed Quilt
Pat Krebs, Fabric Artist & Gene Wright, Photographer

OLD WOMAN CREEK WATERSHED ACTION PLAN

Draft prepared for review by:

Ohio Department of Natural Resources
Ohio Environmental Protection Agency
Ohio State University Extension

Prepared by:

Breann Hohman
Watershed Coordinator
Firelands Coastal Tributaries Watershed Program
Erie Soil and Water Conservation District
2900 Columbus Ave. Room 131
Sandusky, Ohio 44870
419-626-5211

In collaboration with:

Charles E. Herdendorf
Professor Emeritus
School of Earth Sciences
The Ohio State University

Frank Lopez
ODNR – Division of Wildlife

Heather Elmer
ODNR – Division of Wildlife

David Klarer
ODNR – Division of Wildlife

Eric Dodrill
Erie Soil and Water Conservation District



The Firelands Coastal Tributaries (FCT) Watershed Program is a collaboration of government agencies, non-profit groups and local residents working together to enhance, restore, protect our local streams. Primary funding for this program was provided by the Ohio Department of Natural Resources (ODNR) Watershed Coordinator Grant Program, with local sponsorship by the Friends of Old Woman Creek.

June 2009

WATERSHED ACTION PLAN FOR OLD WOMAN CREEK

Cover Photographs: ODNR, ESWCD, Gene Wright

Citation: Hohman, Breann Coordinator 2009 *Old Woman Creek Watershed Action Plan*. Firelands Coastal Tributaries Watershed Program, Erie Soil and Water Conservation District, Sandusky Ohio. [Draft submitted January 2009]

For additional information contact:

Breann Hohman
Watershed Coordinator
Firelands Coastal Tributaries Watershed Program
Erie Soil and Water Conservation District
2900 Columbus Ave. Room 131
Sandusky, Ohio 44870
419-626-5211
www.firelandstributaries.org

Old Woman Creek Watershed Action Plan Prospective Endorsement

We support and agree to pursue implementation of this plan and agree to seek the necessary resources to improve and protect the water quality of Old Woman Creek.

| | | |
|------------------------------------|-----------------------------------|-------------------------------|
| Erie Co. Commissioners | Erie Co. Engineer | Erie Co. Farm Bureau |
| Erie/Huron FSA | Erie General Health District | Erie Co. NRCS |
| Erie Co. OSU Extension | Erie Regional Planning Commission | Erie SWCD |
| Erie Metroparks | Erie Co. DOES | OWC NERR |
| Berlin Twp Trustees | Berlin Heights Village Council | Huron SWCD |
| BGSU Firelands Campus | Friends of OWC | Friends of Pipe Creek |
| Sandusky/Erie Community Foundation | OWC NERR Foundation | Berlin Twp Conservation Club |
| Western Reserve Land Conservancy | Huron Co. Farm Bureau | Ohio Environmental Council |
| NACD Great Lakes Committee | Erie Basin RC&D | Ohio Lake Erie Commission |
| ODNR | Ohio EPA | Ohio Coastal Training Program |

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Acronyms

| | |
|-----------------------|---|
| BCC | Berlin Conservation Club |
| BGSU | Bowling Green State University |
| BHVC | Berlin Heights Village Council |
| BMP | Best Management Practice |
| CNPCP | Coastal Nonpoint Pollution Control Program |
| CREP | Conservation Reserve Enhancement Program |
| CRP | Conservation Reserve Program |
| CSP | Conservation Stewardship Program |
| CTP | Coastal Training Program |
| CWA | Clean Water Act |
| CZARA | Coastal Zone Act Reauthorization Amendments |
| CZMA | Coastal Zone Management Act |
| DOES | Department of Environmental Services |
| DO | Dissolved Oxygen |
| DOW | Division of Wildlife |
| ECGHD | Erie County General Health District |
| ECO | Ecosphere and Associates |
| EMP | Erie Metro Parks |
| EQIP | Environmental Quality Incentives Program |
| ECRP | Erie County Regional Planning |
| ESCD | Erie Soil and Water Conservation District |
| EWH | Exceptional Warmwater Habitat |
| FCT | Firelands Coastal Tributaries |
| FOWC | Friends of Old Woman Creek |
| FSA | Farm Service Agency |
| GIS | Geographical Information System |
| HSTS | Home Sewage Treatment System |
| HUC | Hydrologic Unit Code |
| IBI | Index of Biological Integrity |
| ICI | Invertebrate Community Index |
| IGLD | International Great Lakes Datum |
| LaMP | Lake Erie Lakewide Management Plan |
| LEPR | Lake Erie Protection and Restoration Plan |
| LEQI | Lake Erie Quality Index |
| LRW | Limited Resource Water |
| LLC | Limited Liability Corporation |
| LWD | Low Water Datum |
| Miwb | Modified Index of Well Being |
| MS4 | Municipal Separate Storm Sewer System |
| MWH | Modified Warmwater Habitat |
| NAS | National Academy of Sciences |
| NH₃ | Ammonia |
| NOAA | National Oceanic and Atmospheric Administration |
| NPDES | National Pollutant Discharge Elimination System |

| | |
|-----------------|--|
| NPS | Nonpoint Source |
| NRCS | Natural Resource Conservation Service |
| OAC | Ohio Administrative Code |
| OAHSM | Ohio Association of Historical Societies and Museums |
| OCTP | Ohio Coastal Training Program |
| ODNR | Ohio Department of Natural Resources |
| OEPA | Ohio Environmental Protection Agency |
| OSU | The Ohio State University |
| OWC | Old Woman Creek |
| OWC NERR | Old Woman Creek National Estuarine Research Reserve |
| QHEI | Qualitative Habitat Evaluation Index |
| RC&D | Resource Conservation and Development |
| RUSLE | Revised Universal Soil Loss Equation |
| SDWA | Safe Drinking Water Act |
| SRP | Soluble Reactive Phosphorus |
| SRWC | Sandusky River Watershed Coalition |
| STS | Sewage Treatment System |
| SWCD | Soil and Water Conservation District |
| SWMP | System-Wide Monitoring Program |
| TMDL | Total Maximum Daily Load |
| TWP | Township |
| USEPA | United States Environmental Protection Agency |
| USGS | United States Geological Survey |
| USLE | Universal Soil Loss Equation |
| WAP | Watershed Action Plan |
| WHIP | Wildlife Habitat Incentive Program |
| WRP | Wetland Reserve Program |
| WWH | Warmwater Habitat |

Unit Descriptions

| | |
|--------------|---------------------------|
| CFU | Colonies per forming unit |
| Kg | Kilogram |
| l.ft. | Linear foot |
| L | Liter |
| mg | Milligram |

Executive Summary

A Watershed Action Plan (WAP) combines scientific data with community values to characterize issues that impact the quality of the receiving stream. The planning process identifies impairments to water quality associated with specific land-use practices and then develops strategies to resolve those impairments through partnerships among local, state, and national organizations. Goals and strategies described in this WAP intend to improve, enhance, and protect the waters of Old Woman Creek throughout the watershed by the installation of best management practices (BMPs), initiation of restoration of streambanks and wetlands, and utilization water pollution prevention tools.

Old Woman Creek (OWC) was selected to be the first watershed to receive a watershed action plan in the Erie County area for three reasons: (1) Extensive research and monitoring has inventoried both environmental and sociological aspects of the OWC watershed including a Total Maximum Daily Load report completed by the Ohio Environmental Protection Agency (EPA), (2) Strong existing conservation partnerships could be enhanced through the planning and implementation of a management plan, (3) The management area of OWC is relatively small compared to other regional watersheds, which allows for a more detailed, fine scale approach to project identification and implementation as well as engagement of the watershed's residents.

An Ohio EPA report identified several impairments to OWC including sediment, nutrients, and altered habitat. By developing this WAP, the Firelands Coastal Tributaries (FCT) Watershed Program expects to return OWC to a healthy state while empowering its communities to reconnect with the Creek and ensure a clean, productive stream for future Firelands generations.

Water Quality impairments in OWC described by the Ohio EPA TMDL 2005 report, include sedimentation, excessive nutrients, and habitat alteration. These impairments encompass several sources that contribute to the pollutant loads: agricultural run-off, streambank and in-stream erosion, improper wastewater treatment, and reduction of riparian buffers and wetlands. Through the use of the OWC WAP, the FCT expects to bring the watershed into full attainment while empowering the community to take ownership of their water resource. This will ensure a clean, clear, productive stream for future generations.

Note to the Reader

This plan is divided into chapters beginning with background information about the purpose of this watershed action plan and the importance of watershed management (Chapters 1 and 2), an overview of policies and programs focused on water resource protection (Chapter 3), a detailed inventory of the OWC watershed (Chapter 4), and a description of water quality impairments (Chapter 5). The last two chapters describe identified impairments in association with pollutant reduction goals (Chapter 6) and develop strategies for achieving those goals and evaluating progress (Chapter 7).

The plan should be used as a guide for future remediation efforts in the OWC watershed and a resource for expediting the grant application process for implementing each strategy. To aid the reader, each chapter begins with a short summary of contents and material covered in that section of the plan. Chapters 1-5 provide detailed information to be used to apply for grant funding and seek support from the community through education. Chapter 6 provides detailed timeline and resource information for each strategy to begin the implementation process.

Acknowledgements

FIRELANDS COASTAL TRIBUTARIES WATERSHED PROGRAM (FCT)

Working toward environmental improvements at the local level is no easy task, nor is it something new for our communities. Money is always scarce and time is always short. Despite the challenges faced by these groups, it is the willingness to partner, sharing resources, expertise, and commitment that makes environmental improvements possible. The increase of watershed awareness in the Firelands area would not have been possible without the partners of the FCT. Many of these groups have been championing the importance of conservation for years and developed valuable partnerships along the way. By refining these partnerships through the mutual goals of the FCT, resources, knowledge, and enthusiasm are shared to enhance and protect local streams and our state's most valuable natural resource, Lake Erie.

The support from these groups is indicative of the grassroots efforts seen in watershed conservation through the nation. The FCT partners realize our home is truly a unique place that needs to be protected for the enjoyment of future generations. Our work may never be done, however our determination and willingness to work together will always inspire residents to be engaged for the common good of their communities and our most critical resource. The FCT is a partnership and would not exist without the commitment of community, for which we thank you. We would also like to give a special thank you to the Friends of Old Woman Creek, who fearlessly sponsored the grant to initiate the FCT program and to develop the OWC WAP. The Friends continued support of the FCT has cultivated community engagement which will be the catalyst for implementation of this plan.

FCT Partners and Supporters

Friends of Old Woman Creek
Erie Soil and Water Conservation District
ODNR-Division of Wildlife/Old Woman Creek National Estuarine Research Reserve
Bowling Green State University
Erie Metroparks
Western Reserve Land Conservancy-Firelands Chapter
EcoSphere Associates
Sandusky/Erie County Community Foundation
Meadow Environments LLC
Erie County Health Department
Old Woman Creek National Estuarine Research Reserve Foundation Fund
(Columbus Foundation)
Huron Soil and Water Conservation District
Ohio Environmental Council

Friends of Pipe Creek Watershed
Erie County Department of Environmental Services
ODNR Office of Coastal Management
ODNR Division of Wildlife
ODNR Division of Soil and Water Conservation
National Oceanic and Atmospheric Association
Ohio Sea Grant College Program
OSU Extension
Ohio Environmental Protection Agency
Erie County Farm Bureau
Erie County Commissioners
Berlin Heights Village Council
Barnes Nursery
Tribs Team Volunteers
Erie County NRCS
Erie County OSU Extension Office
Erie County Regional Planning Commission
Erie County Engineers
Sandusky River Watershed Coalition
Haag Environmental
Berlin Conservation Club
City of Sandusky
Lake Erie Commission
Erie RC&D
Huron Township Trustees
Berlin Township Trustees
Groton Township Trustees
Perkins Township Trustees
Ed Singer, Perkins-250 LLC
Larry Bettcher
Sandusky Rotary Club
Erie County Master Gardeners
Huron County Master Gardeners
River Network
Christy Seyler
The Erie County Volunteer Center

OLD WOMAN CREEK WATERSHED ACTION PLAN (WAP)

The development of the Old Woman Creek Watershed Action Plan was a dynamic process made possible only through tireless efforts of FCT partners, specifically the participants of the WAP Workgroup. The group was a wealth of knowledge and support that truly made this document a reality. The plan is indebted to the support of Charles (Eddie) Herdendorf and Dave Klarer, for submission of maps, data, and use of the Old Woman Creek Site Profile as a direct source for information for the

Watershed Resource Inventory (Chapter 4). The Site Profile is an amazing resource any watershed coordinator would covet, but would take several hours to paraphrase its content into the plan. Thank you for streamlining this process. Eddie and Dave also offered suggestions for WAP content and reviewed the final draft. Heather Elmer, Frank Lopez, and Eric Dodrill provided several contributions to the Watershed Approach (chapter 3). There are additional documents that sculpted this plan, if not for the help of Heather, Frank, and Eric, I might still be reviewing those documents. They also served as early draft reviewers of selected chapters and the final draft. Gloria Pasterak helped to format the plan and did final edits of the document, and also kept detailed minutes at workgroup meetings that were valuable in producing a document that reflected the ideas of the participants. I have learned first hand that formatting can be a nightmare; thank you, Gloria for helping me through it. Mapping was essential in understanding the watershed and providing the reader with visual representations of the watershed; Steve Barry not only developed several maps found in this plan but also provided spatial data analysis. I would also like to thank the Sandusky River Watershed Coalition for permission to use their summaries of several environmental policies that affect watershed efforts in Ohio.

WAP (Document) Workgroup

Breann Hohman – Writer/Organizer/Editor
Eddie Herdendorf- Writer (Inventory)/Reviewer
Dave Klarer – Data Analysis/Reviewer
Heather Elmer – Writer (Policies)/Reviewer
Frank Lopez – Writer (Programs)/Reviewer
Eric Dodrill – Writer (Policies)/Reviewer
Gloria Pasterak - Editor/Reviewer

Photos

Heather Elmer, ODNR-Wildlife, Ohio Coastal Training Program Coordinator
Gene Wright, ODNR Office of Coastal Management – Asst. Chief (acting)
Pheobe VanZoest, ODNR-Wildlife, Education Specialist
Marje Bernhardt, ODNR-Wildlife, Administrative Assistant
Breann Hohman, Erie SWCD, Watershed Coordinator

Mapping

Steve Barry, ODNR-Wildlife, Wetland Habitat Coordinator

Chapter 1. Introduction

Purpose

In this chapter, the reader will find information about how watershed planning and the “watershed approach” has been enhanced through the development of the Firelands Coastal Tributaries Watershed Program. This chapter is designed to be a resource for educating potential partners to engage in the efforts of the FCT.

Chapter Acknowledgements

This chapter was prepared using material from *The Sandusky-Tiffin Watershed Action Plan* by permission, and by the watershed coordinator and the FCT partners.

PURPOSE OF THE WATERSHED ACTION PLAN

The purpose of the Old Woman Creek Watershed Action Plan (WAP) is designed to reduce the causes of impairment within the watershed in stream reaches that do not currently meet water quality standards and protect areas that are meeting standards. In OWC (OWC), we hope to reduce sediment and nutrient loading while increasing habitat quality through creation of riparian buffers and wetlands. In areas considered essential for the sustainability of the watershed (ie., riparian corridors), we hope to ensure integrity through use of setbacks, conservation easements, and other stewardship activities.



Figure 1: Members of the Friends of Old Woman Creek enjoying a canoe trip through the estuary at their annual Lotus Float. (ODNR)

In this document, the reader will find an overview of watershed science and current local, state, and federal policies and programs geared toward water quality efforts; a detailed inventory of the OWC watershed, and goals and strategies for improving and protecting the watershed.

Why Old Woman Creek?

Residents and visitors of northern Ohio use Lake Erie as a source of recreation, drinking water, commerce, transportation, as well as for waste disposal, power production and industrial development. The sustainability (i.e, the integrated economic, environmental, and social well-being) of communities within OWC and neighboring watersheds is inextricably linked to Lake Erie. The estuary at the mouth of OWC is one of the few remaining examples of a naturally functioning freshwater estuary along Lake Erie's south shore. If not overloaded or degraded, estuaries and coastal wetlands help to protect Lake Erie water quality by trapping sediments and pollutants. Improving water quality in OWC would help to sustain this rare and valuable natural resource and the ecosystem services it provides. The unique climate created by the proximity of Lake Erie make OWC a niche for specialized agriculture (fruit farms and vineyards) as well as desirable place to live. Therefore water quality is critical for continued growth in our coastal economy of agriculture, recreation, and tourism.



Figure 2: Apple orchards in Old Woman Creek watershed. (Hohman)

In 2004, social scientists conducted a social assessment of the OWC watershed through analysis of census data, interviews and community focus groups. Strong emotional and historical ties to OWC and its estuary were a consistent theme among residents interviewed in this study. In addition, both interview and focus group results suggest that the region comprising the OWC watershed is changing. This study recommended that the strong community ties that exist within the watershed could be the driving force for the protection and restoration of local streams. This combined with a small management area, allows planning efforts to focus in detail on the water quality impairments of the watershed and community concerns related to future growth and sustainability.

The Creek...



The Estuary...



And Barrier Beach.



Figure 3: Three distinct ecosystem community types found in Old Woman Creek watershed: stream, estuarv, and lake. (Elmer)

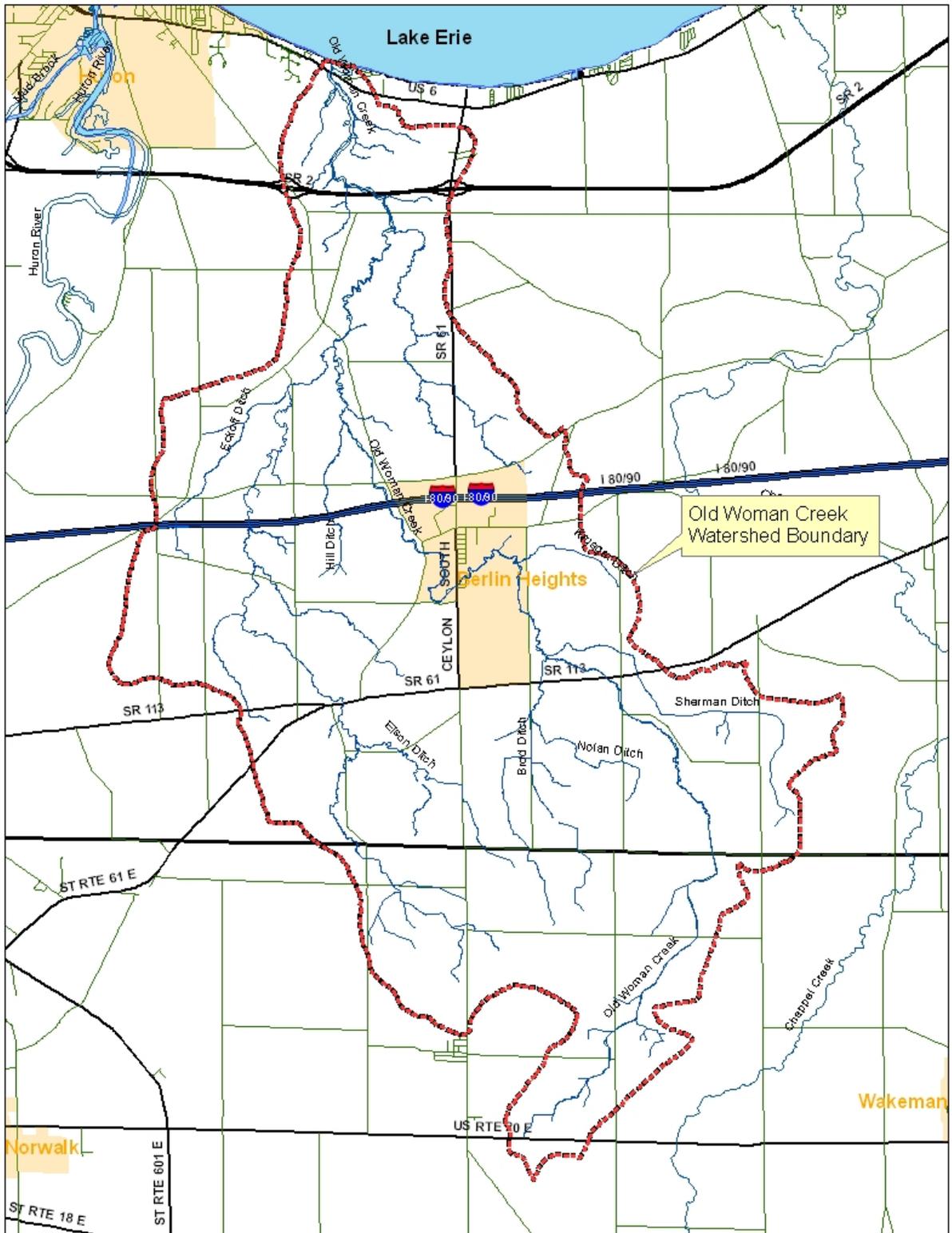


Figure 4: Old Woman Creek watershed, HUC code 04100012 040 020 (ODNR)

What is a watershed action plan?

A watershed action plan (WAP) provides an accounting of natural resource management objectives, including problems and concerns, and activities that watershed stakeholders will pursue to improve their watershed. A WAP is the product of a dynamic process of engagement of the watershed citizenry and other interested parties and serves as a guide for the local implementation of conservation efforts (i.e. watershed management). Figure XX illustrates “Implementing the Watershed Approach” as adopted by the Ohio Environmental Protection Agency (OEPA, 1997).

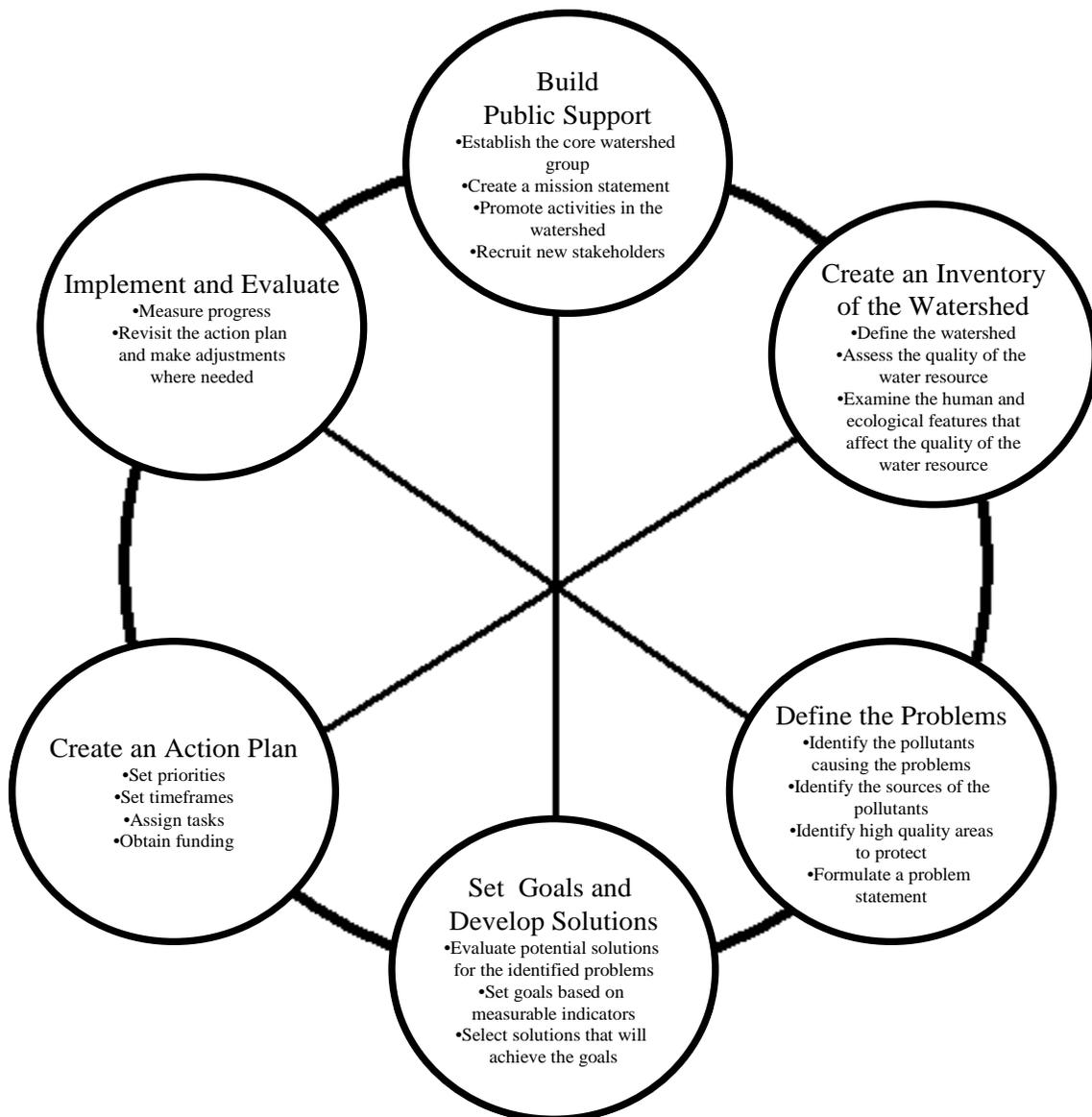


Figure 5: “Implementing the Watershed Approach” as adopted by the Ohio Environmental Protection Agency (OEPA, 1997).

What is watershed management?

Watershed management is an adaptive process of collaborative decision-making that is typically driven from either the bottom up, by local concern for the sustainable use of a highly valued natural resource, and/or from the top down, by federal and state laws that are designed to safeguard a resource. Watershed management can be comprehensive in scope, but at a minimum seeks to maintain or restore the chemical, biological, and physical integrity of water resources while safeguarding the economic good of the local communities involved. Watershed management factors include water quality and water quantity, and the impact of both on public health and well being.

The watershed is the ideal basis for natural resource planning, providing an appropriate physical context for implementing land use planning and ecosystem management, and an area that lends itself better to understanding the relationships between natural and manmade phenomena and water quality. The watershed as a planning and management unit is also beneficial for promoting interagency coordination and information sharing. The watershed can be a conduit-serving to focus policies and strategies for surface and groundwater resource management. Community based watershed management enables the local community to align of state water resource programs by watershed and enhance intra- and interagency cooperation at local, state, and federal levels.. Thus, achieving environmental objectives regarding Ohio's surface and groundwater requires addressing the strategic need for watershed management.

Firelands Coastal Tributaries Watershed Program

The Firelands Coastal Tributaries (FCT) Watershed Program is a diverse group of government agencies, non-profit groups and local residents working together to enhance, restore, and protect our local streams. The FCT program was made possible through hiring a Watershed Coordinator with financial assistance from the Ohio Department of Natural Resources (ODNR) Watershed Coordinator Grant Program in 2007. The FCT program plans to use the OWC Watershed Action Plan (WAP) as a model to develop future management plans for other direct tributaries of Lake Erie in the Firelands area.

FCT partnerships include representatives from state and local governments, as well as businesses, non-profit organizations, and local residents. FCT has developed technical sub-committees in which stakeholder interest and expertise are best utilized. Each partner is encouraged to have at least one representative in a sub-committee.

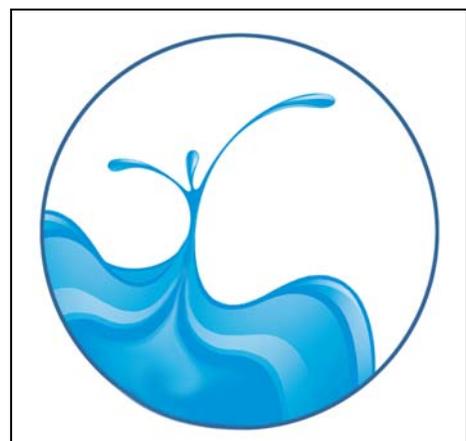


Figure 6: FCT Logo

Table 1. Key Stakeholders of the FCT

| Partner | Organization Type | Primary Role(s) |
|---|---------------------------|--------------------------|
| Berlin Heights Historical Society | Civic group | Outreach/Technical |
| Berlin Heights Village Council | Local government | Technical/implementation |
| Berlin Twp. Conservation Club | Civic group | Volunteer |
| Berlin Twp. Trustees | Local government | Technical/implementation |
| BGSU Firelands Campus | Academic Institution | Educational |
| Eco-sphere Assoc. | Business | Technical/Research |
| Erie County Commissioners | Local government | Financial/Technical |
| Erie County DOES | Local government agency | Educational/Technical |
| Erie County Farm Bureau | Non-profit group | Outreach/financial |
| Erie General Health District | Local government agency | Technical |
| Erie Metroparks | Local government agency | Educational |
| Erie NRCS | Federal government agency | Technical |
| Erie Basin RC&D | | |
| Erie SWCD | Local government agency | Administration/Technical |
| FCT Area Residents | Local citizens | Volunteer/Technical |
| Florence Twp Trustees | Local government | |
| Friends of Old Woman Creek | Non-profit group | Sponsor/Outreach |
| Friends of Pipe Creek Watershed | Civic group | Volunteer/Outreach |
| Huron Twp Trustees | Local government | Technical |
| Huron General Health District | Local government agency | Technical |
| Huron SWCD | Local government agency | Technical |
| Larry Bettcher | Local citizen | Financial |
| Meadow Environments Inc. | Business | Technical |
| Ohio Environmental Council | Non-profit group | Technical |
| OWC NERR/ODNR-Wildlife | State government agency | Technical/Educational |
| Sandusky/Erie Community Foundation | Non-profit group | Financial |
| The Volunteer Center of Erie County | Non-profit group | Outreach |
| Townsend TWP Trustees | Local government | |
| Wakeman TWP Trustees | Local government | |
| Western Reserve Land Conservancy- Firelands Chapter | Non-profit | Technical |

Sub-committees meet as needed to discuss on-going projects with a minimum of four meetings a year. Every six months, the Firelands Coastal Tributaries partners meet at a networking luncheon to receive updates on recent accomplishments, announce future grant funded projects, and to provide feedback on the development of the OWC WAP. Once the WAP has been completed, these meetings will serve as additional evaluations for the WAP implementation phase.

Advisory Board. The advisory board serves as the oversight and policy setting body of the FCT watershed program. FCT Council events and public meeting planning is part of the responsibility for this board as well as oversight of the FCT

program, budget, and development of the OWC WAP. The board serves as the primary advisor to the watershed coordinator. This committee is comprised of representatives from Erie Soil and Water Conservation District (ESWCD), OWC State NERR, and the Friends of Old Woman Creek (FOWC):

Frank Lopez, ODNR-Wildlife, OWC NERR, Reserve Manager
Eric Dodrill, ESWCD District Director
Elaine Waterfield, FOWC Board Member
Charles Waterfield, FOWC Member
Steve Deehr, ESWCD Board Member

Additional Committees have also been established to serve as workgroups for the development of the WAP and various FCT functions. Each committee is made of representatives from partner organizations and local residents. Decisions are made through consensus of the attending representatives.

Education

Phoebe VanZoest, ODNR-Wildlife
Ron Nemire, Teacher, Berlin-Milan Local Schools, OWC watershed resident
Lois TerVeen, EMP
Cindy Brookes, SRWC
Celine Hemminger, ESWCD
Tina Sevenbergen, DOES
John Blakeman, Meadow Env't.
Bill Monaghan, Erie Co. Commissioner

Land Use and Development

Ed Enderle, Huron Twp Trustee
Cary Brickner, HSWCD
Nancy Mckeen, Erie Co. Commissioner
John Blakeman, Meadow Env't.
Rocemi Morales, NRCS

Monitoring

Dr. Linda Cornell- BGSU/Firelands
Dave Klarer, ODNR-Wildlife
Charles Herdendorf, EcoSphere Associates/OSU Earth Sciences
Barry Riddle, FPCW

Habitat and Restoration

Andrew Shella, Terra Community College
Steve Barry, ODNR-Wildlife
Richard Sinwald, City of Sandusky
Dean Sheldon, Erie Co. Resident

Source Contaminant

Chris Stelzer, ECGHD
Heather Elmer, ODNR-DOW
Bob England, ECGHD

Grants and Fundraising

Lisa Beursken, DOES
Frank Lopez, ODNR-Wildlife
Eric Dodrill, ESWCD
Elaine Waterfield, FOWC
Kathy Mueller, FPCW

Chapter 2. Watershed Science Overview

Purpose

In this chapter, the reader will find information about the science of watersheds including, geographic scale, the water cycle, ecosystem dynamics, and water pollution, whether from a known source or not. This chapter is designed to be an education resource for understanding how watersheds work and how watersheds are affected by land use.

Chapter Acknowledgements

This chapter was prepared utilizing modified sections from *The Sandusky-Tiffin Watershed Action Plan* by permission, and by the watershed coordinator and the FCT partners.

WHAT IS A WATERSHED?

The watershed of any lake or river encompasses all the land that drains directly into it or into its tributaries. Watersheds vary in size and can range from a small area within one's back yard to that of the Mississippi-Atchafalaya River Basin, the largest river basin in North America, draining an area of 3.2 million square kilometers, or about 41% of the lower 48 United States. Thus, watersheds at the smallest scale are typically nested hierarchically within larger watersheds.

The watershed map on the following page shows this for OWC as its watershed is nested within the larger Huron-Vermilion basin. The Huron-Vermilion watershed lies within the still larger Lake Erie basin incorporating parts of five states and one Canadian Province. Although OWC is classified as being part of the Huron-Vermilion basin, it is unique because it flows directly into Lake Erie without entering either larger river system. This direct connection makes OWC a coastal tributary of Lake Erie.

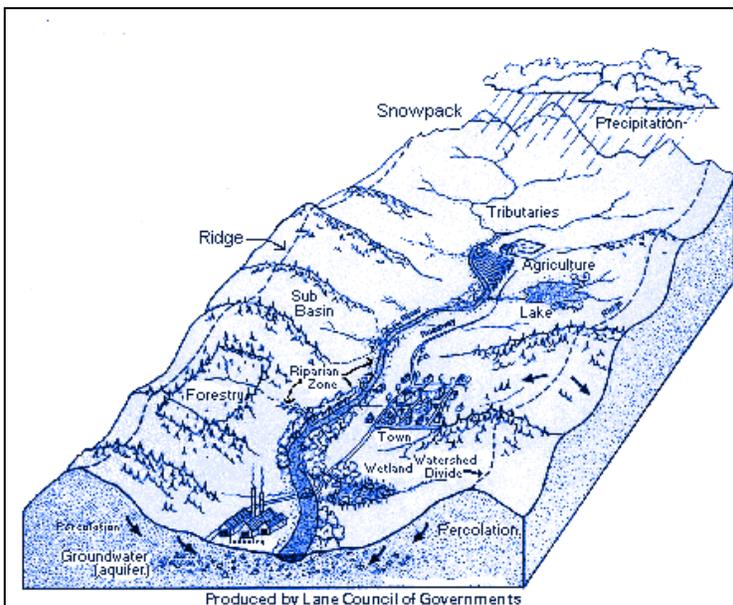


Figure 7: Watershed diagram

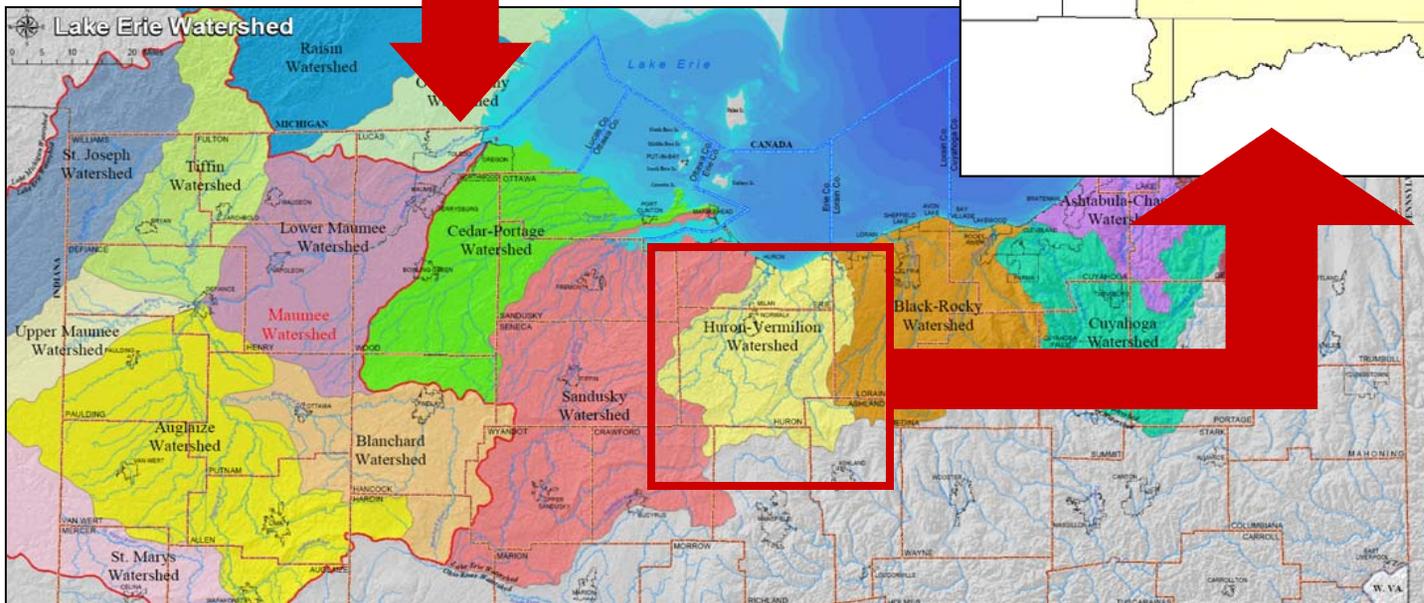


Figure 8: Watershed hierarchy of the Great Lakes watershed (top left), Ohio's Lake Erie watersheds (bottom), and Old Woman Creek as a sub-watershed in the Huron-Vermilion watershed system (top right). (ODNR)

Water Cycle

All the water on Earth is stored in three reservoirs: surface water (streams, lakes, oceans, glaciers), underground (groundwater), and atmosphere (clouds). Essentially, water travels through these reservoirs by a process known as the water cycle. Water that falls from the sky may become run-off, infiltrate into the ground, or evaporate/transpire back into the atmosphere depending on the conditions of the area. Once water has returned to the atmosphere, it has completed the process and starts the cycle again. Water is fundamental to the climate system of the Earth. As water circulates through the process, weather conditions are distributed throughout the Earth creating various landscapes and ecosystems. The Great Lakes, for example, naturally maintain their water quantity through the inflows (precipitation and run-off) and outflows (evaporation and discharge to the Atlantic Ocean) as part of the global water cycle. The Great Lakes also impact the climate through the creation of “Lake effect” conditions in relation to the lakes serving as a giant heat sink and humidifier moderating temperature and increasing winter precipitation in the form of snow belts to the surrounding region.

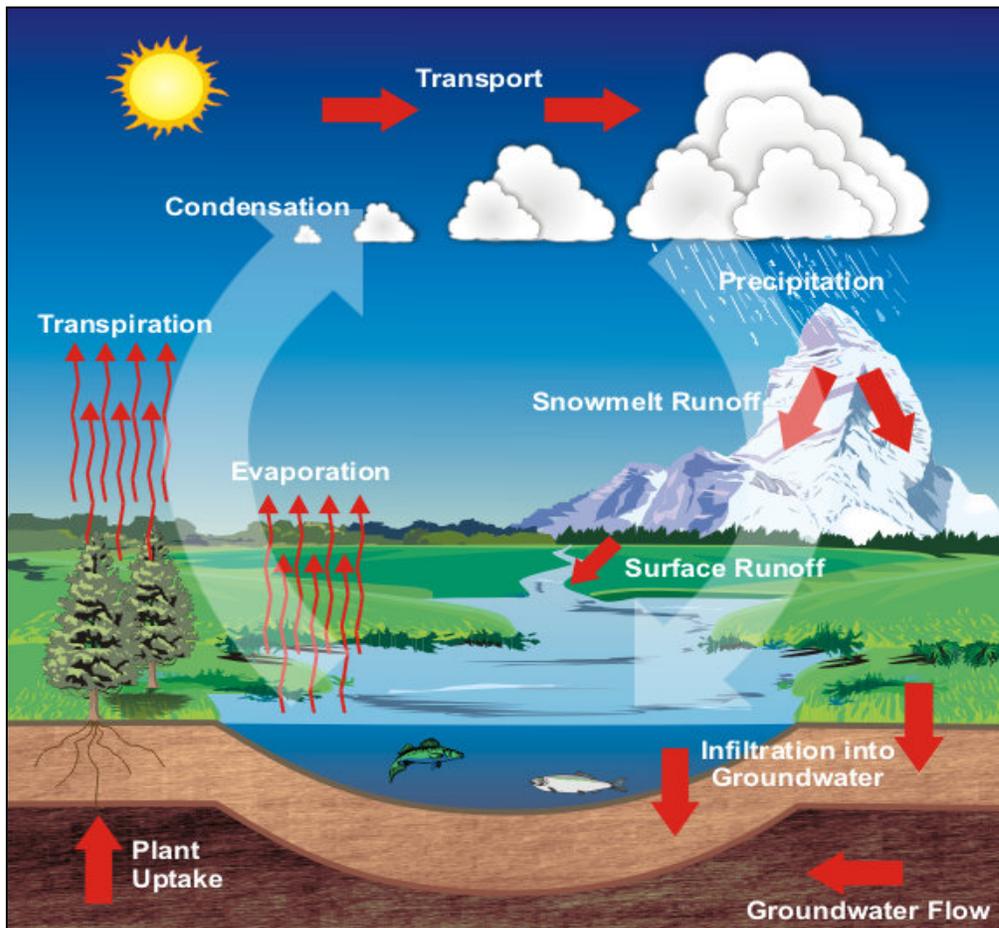


Figure 9: The Water Cycle. (USEPA)

<http://www.epa.gov/watertrain/ecology/s7.jpg>

Watershed Ecology

Understanding the structure and processes of watersheds helps us better recognize the effects of human activities on water quality, habitat, plant and animal communities, and quality of human life. Watershed dynamics can be separated into three categories: chemical budgets, water budgets, and biotic structure. In a healthy watershed all three factors are in balance. If one of the factors is impacted, for example loss of the riparian zone (biotic structure), the other factors will be impacted. Riparian zones have a variety of definitions; however, they generally refer to an area of vegetation usually including woody species that transitions the immediate landscape from the water edge to the adjacent upland. A healthy, natural riparian zone, often referred as a “buffer”, provides essential functions to filter excess nutrients (chemical budget) from entering the stream and flood storage (water budget) that could result in downstream impacts. If the riparian habitat is removed, an imbalance is created in the dynamics of the ecosystem that often results in negative impacts on aquatic and terrestrial life native to the watershed. In our local watersheds, losses of riparian buffer and non-point source pollution are the greatest stressors impacting streams.

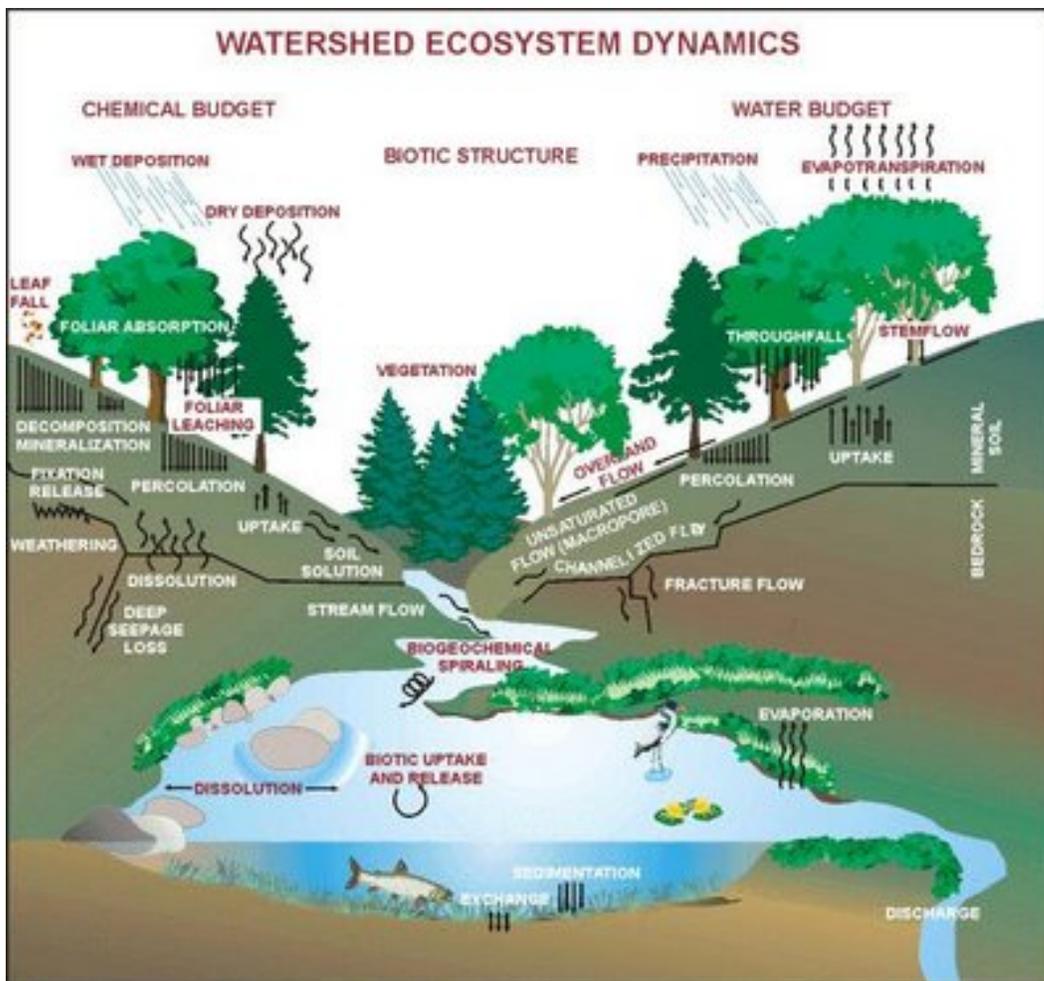


Figure 10: Watershed ecology diagram demonstrating modes of movement of water and chemical factors and their relation to the biotic structure.

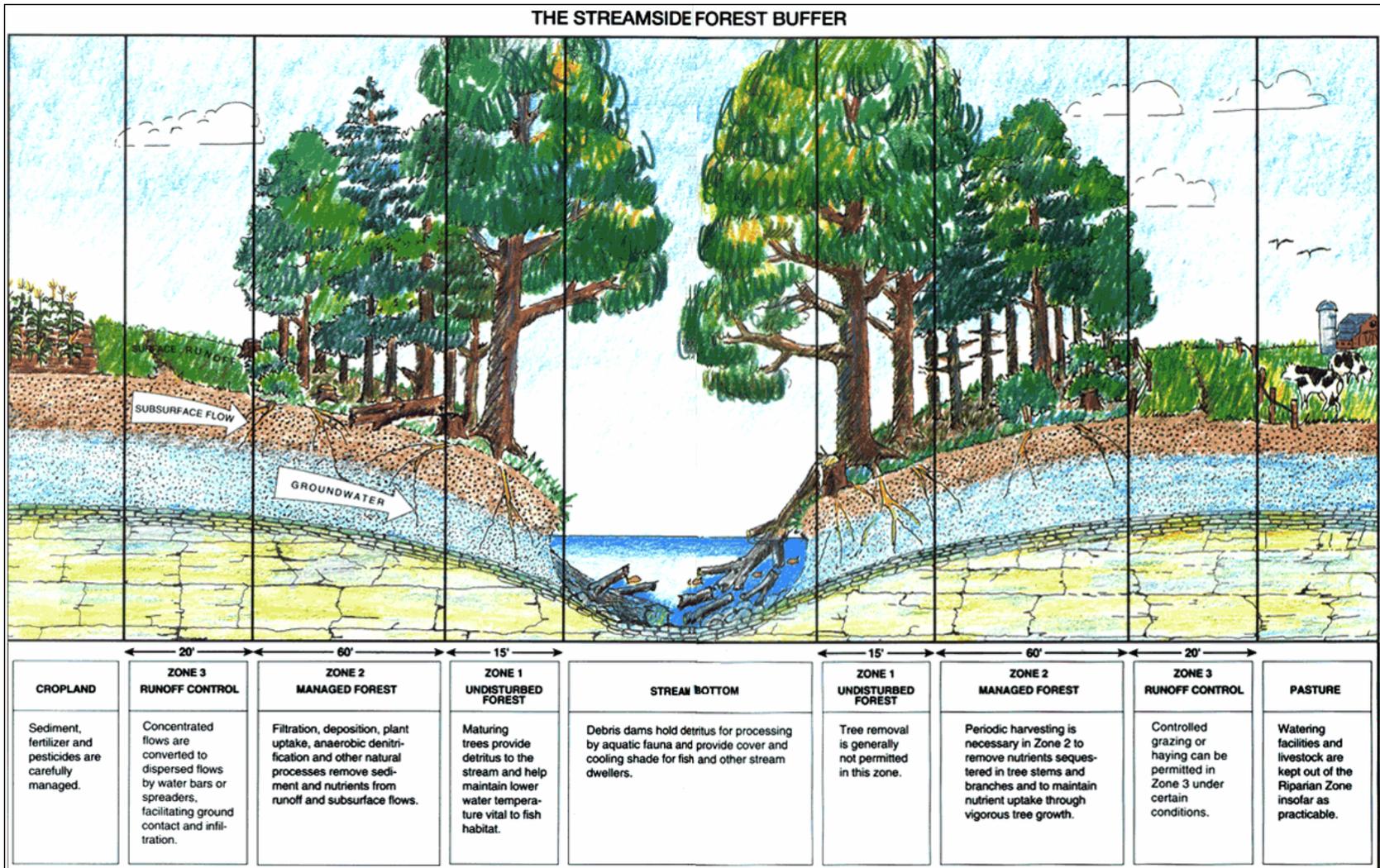


Figure 11: Example of a forested riparian buffer and benefits of various vegetation zones for pollution reduction and maintaining stream health.

What is Nonpoint Source Pollution?

Nonpoint source (NPS) pollution, unlike pollution from industrial and sewage treatment plants, comes from diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, depositing them into lakes, rivers, wetlands, coastal waters, and even our underground sources of drinking water. These pollutants include:

- **Excess fertilizers, herbicides, and insecticides** from agricultural lands and residential areas
- **Oil, grease, and toxic chemicals** from urban runoff and energy production
- **Sediment** from improperly managed construction sites, crop and forest lands, and eroding streambanks
- **Salt** from winter road practices and acid drainage from abandoned mines
- **Bacteria and nutrients** from livestock, pet wastes, and faulty sewage treatment systems

(Source. EPA's Polluted brochure EPA-841-F-94-005, 1994)

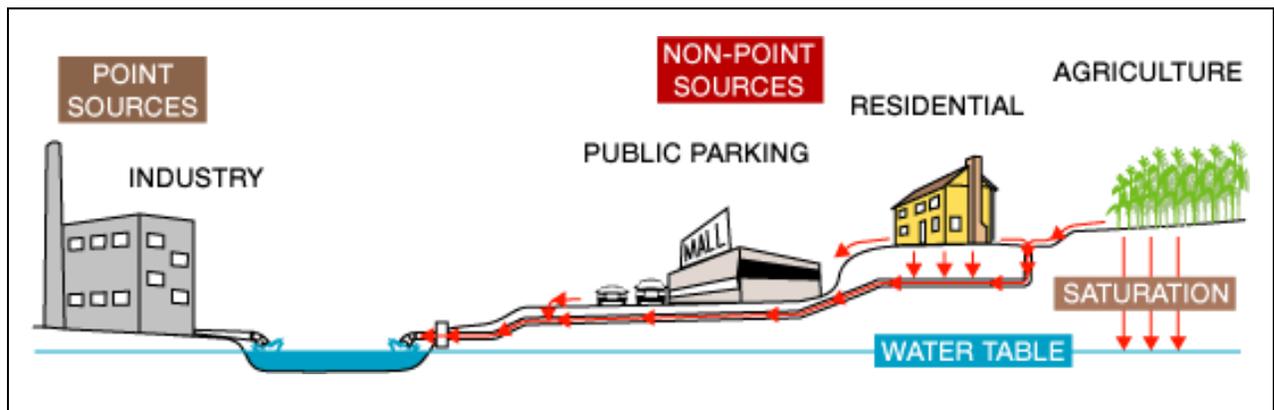
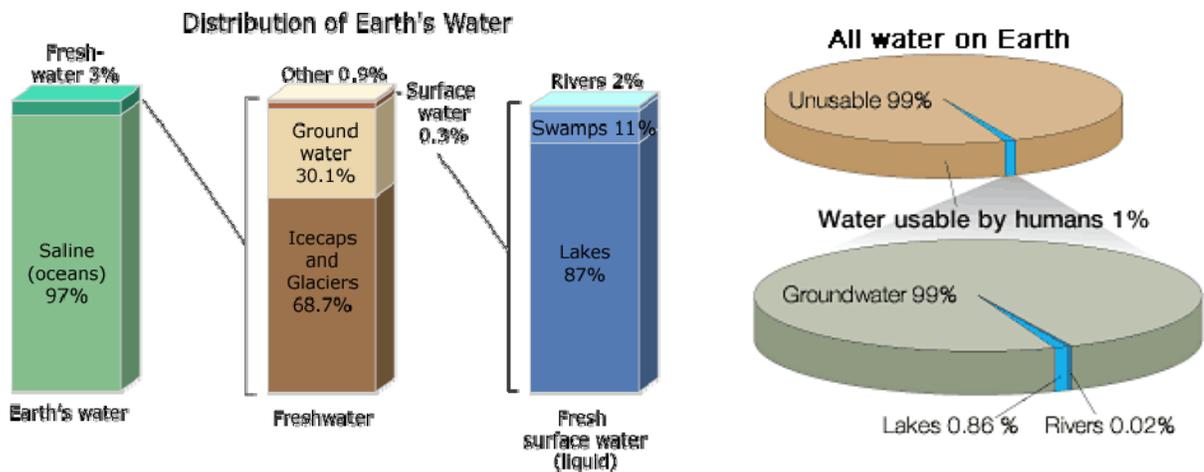


Figure 12: Point and Non-point pollution sources (Indiana County Conservation District, 2008)

Clean Water and Quality of Life

Living next door to one of the world's largest natural fresh water supplies (Lake Erie) often creates apathy for importance of this natural resource and the impacts our existence has on it. Consider this; about two thirds of the Earth is covered by water, 97% saltwater (oceans) and only 3% freshwater. The useable freshwater in the world is further divided into glaciers/icecaps, groundwater, and surface water as seen below. Essentially the USDA depicts our useable water as being only 1% of all the water on Earth. Because water is an essential element to life, protecting the quality of that usable 1% should be at the top of our priorities.



To investigate the relationship of water and quality of life, you must consider the definition of the latter. Quality of life refers to the level of satisfaction of one's life and surroundings which may be influenced by many factors such as personal health, opportunity, safety, and the environment (ie. open space and pollution). The use of "quality of life" is often described in determining the best locations in the world to live and supporting of need for community improvements. Quality of life, being subjective by nature, is very difficult measure. The Mercer company, who develops list of the "best places to live", surveys communities worldwide based on 39 criteria which they believe to represent living standards offered by a community that affect the quality of life of the resident. Although they due not specifically survey the health of watersheds or the quality of the water associated with the community, several categories such as public services, housing, recreation, economy and safety are directly impacted by the health of the watershed in that community.

Public Services: Drinking Water a Lesson from New York City

In 2008, the Forbes magazine listed Des Moines (IA), Austin (TX), as Sioux Falls (SD) having the best drinking water in the United States. These communities also have established watershed protection programs as part of their public works provided by the local government in collaboration with State, Federal, and non-profit organizations. The quality of the local watershed and the quality of the processed water are dependent. Odor, color, turbidity, and pathogens are all common parameters that are treated during the water treatment process. Having small amounts of these substances in the primary water source ultimately leads to cleaner better tasting drinking water with less processing cost.

New York City was faced with upgrading their water treatment system by adding a filtration plant that was estimated to cost between \$6-10 billion for construction and an additional \$110 million in annual operation cost. The location of the city is downstream of Catskill/Delaware watershed which had increasing nonpoint source pollutants entering the stream creating a need for the water treatment improvements. The cost of the system upgrades were compared to the costs of developing a watershed protection program to reduce the pollutant loadings to the stream. What they found was the watershed program would cost a fraction of what was needed for water treatment improvements (approximately \$100 million annually). As a result the city chose to work towards several watershed approaches such as protecting and enhancing riparian forested buffers which has averted the need to make costly improvements to their drinking water infrastructure.

Housing: Clean Water Equals Higher Property Values

Lake Erie is the most populated lake of all the Great Lakes, boasting 11 metropolitan communities located on its shores. Between 1982 and 1997, the amount of urban land use in the bordering counties of the lake increased by 24.4% (Ara, et al. 2006). This expansion of the housing market followed a period of significant water quality improvements for Lake Erie after the installation of the Clean Water Act. To investigate water quality's potential relationship to housing values a study completed by Ara (et al. 2006), compared water quality data (fecal coliform counts and turbidity readings) with housing/neighborhood data (price, proximity to beach, school district, and census data). They found water clarity alone increased property values by 4-5% which was equivalent to having a home in a better school district.

Recreation: Water Quality impacts on Beaches and Fishing

Swimming beaches are an important part of tourism and life on Lake Erie. Beach closures have become increasingly prevalent as bacterial level exceedances have led to water quality advisories. During the summer of 2007, the number of water quality advisories increased by 25% at some Erie County beaches. These advisories are reported when the bacterium *E.coli* reaches levels harmful to human health. *E.coli*, which is found in human and animal waste, enters our waterways through improperly treated domestic waste water (failing septic systems and combined sewer overflows) and agricultural run-off (field manure run-off and livestock access to streams). In addition to the bacterial pollution caused by untreated waste, nutrient levels also increase leading to algal blooms in Lake Erie.

It is estimated that harmful algal blooms cost the U.S. \$50 million a year,” said House Representative Vernon Ehlers of Michigan, who chairs the subcommittee. “Harmful algal blooms are also causing problems closer to my home, the Great Lakes, where these events are more and more frequently fouling the water. In the past 30 years major advances were made to improve Great Lakes water quality, but recently scientists have observed an increase in harmful algal blooms. The reasons for this are unclear, but may be related to invasive species changing the way nutrients are cycled in the lakes’ (Carmichael, Wright State University). Understanding the water quality impacts and developing ways to reduce those impacts has and will continue to be top priorities for many government and academic organizations such as Ohio EPA, ODNR, and Ohio Sea Grant. Lake Erie is considered Ohio’s greatest natural resource; frequently producing more fish for human consumption than the other four Great Lakes. Moreover, Lake Erie supports the largest sport fishery in the Great Lakes and the largest freshwater commercial fishery in the world.

Economy: Tourism and a Healthy Lake Erie

Outdoor activities are third on the list of top activities for domestic travelers, and in 2004 all top-10 destination state for traveling in the US was coastal states (Sea Grant). Lake Erie Tourism in Ohio accounts for more than \$10.7 Billion in revenue, employing 119,100 Ohio residents and more than \$750 million in state and local tax dollars. Melinda Huntley, Tourism Director for Ohio Sea Grant stated, Tourism and the environment are so interrelated...Tourism is viewed as an economic driver, but in reality, it has the ability to impact and be impacted by the environmental quality.”

Safety: Lack of Planning, Present Flooding

It is no question that increase impervious surfaces (roads, roofs, parking lots) increase the amount of stormwater entering our waterways. Managing stormwater, however was not always part of the development planning. During the postwar area the need for affordable housing created a development boom in many cities. As a result “natural” and agricultural landscapes which had the capacity to infiltrate rain water were converted to the neighborhood and shopping centers with no concern for stormwater detention. Today we are beginning to see the effects of those planning choices. Storm events create extreme fluctuations in stream volume and velocity. As a result streambanks erode to accommodate the high flows which often can damage existing infrastructure such as roadways and bridges. Abrupt changes in stormwater volume entering a stream may also result in downstream flooding. Many neighborhoods in the Firelands area are now experiencing this flooding response to improperly managed stormwater. Although the damaging effects of stormwater can be decreased overtime with management and retrofitting, preplanning is the more cost-effective way of dealing with this issue.

Chapter 3. Watershed Approach

Purpose

In this chapter, the reader will find an overview of environmental laws and conservation programs that serve as the policy support and development framework for this plan. This chapter is designed to be a quick resource to help readers understand the framework for watershed management locally and at broader scales.

Chapter Acknowledgements

This chapter was prepared using material from *The Sandusky-Tiffin Watershed Action Plan* by permission, the WAP workgroup, and inventory and research completed by the watershed coordinator and FCT partners.

ENVIRONMENTAL POLICIES AND PROGRAMS

Two significant federal acts are at the heart of our nation's watershed approach for protecting or improving our nation's waters:

- 1) Federal Water Pollution Control Act Amendments of 1972 and 1987 (aka, the Clean Water Act)
- 2) Safe Drinking Water Act of 1974 (Public Law 93-523).

Additionally, a third piece of legislation significant for OWC is the Coastal Zone Management Act, signed into law in 1972. The estuary of OWC lies within the State of Ohio's designated coastal zone. All three federal laws have been amended at least once since their enactment in the 1970s. In concert with federal law, several state laws and programs are also relevant to watershed planning and will be highlighted along with regional and local policies and programs that influence land use activities in the OWC watershed.



Figure 13: The Cuyahoga River, past and present. A 1969 in-stream fire similar to the one shown above was the catalyst for passing the Clean Water Act, which was instrumental in water quality improvements around the country

Clean Water Act (CWA)

Selected programs of importance that resulted from the CWA include the Total Maximum Daily Load (TMDL) program, Section 319 nonpoint source management programs, and a permitting system called the National Pollutant Discharge Elimination System (NPDES) that includes the Storm Water Program are relevant for OWC.

When the CWA was reauthorized through the Water Quality Act of 1987, new emphasis was placed on the importance of controlling nonpoint sources of pollution. Section 319 of the CWA compels states to identify waters that are threatened by nonpoint sources of pollution and develop programs to reduce and eliminate this type of “poison runoff”. The State of Ohio is in the process of updating its nonpoint source pollution program.

Total Maximum Daily Load Program (TMDL)

The TMDL program was established under Section 303(d) of the CWA to assess water quality of surface waterbodies (e.g., streams, lakes) and develop recommendations for pollution reduction to meet specific water quality standards. The process includes an assessment of waterbody health (biological, chemical, and habitat), the development of a restoration target, and recommendations for implementing solutions, and validation to monitor progress. This program is essentially a pollutant “budget” for restoring impaired water bodies in order that they may fully attain designated use(s). Regulations that the US Environmental Protection Agency (USEPA) set forth in 1985 and amended in 1992 remain in effect for the TMDL program.

The State of Ohio, much like all other states, is compelled by law to assess the quality of state waters relative to their designated use(s), identify waters that are impaired for one or more of their designated uses, and develop a TMDL for remedial action where appropriate. The “Total Maximum Daily Loads for the Old Woman Creek/Chappel Creek Watersheds – Final Report” is a product of this program that was developed by the Ohio Environmental Protection Agency (OEPA) and released to the public in 2005.

National Pollutant Discharge Elimination System (NPDES) Stormwater Program

The NPDES Stormwater Program was developed by the USEPA in response to the 1987 Amendments to the CWA. The Phase I program was implemented in 1990 and requires discharge permits for medium and large municipal separate storm sewer systems (MS4s) located in cities and counties with populations of 100,000+, selected industrial activity, and construction activity with soil disturbance of 5+ acres. At the end of 1999, the USEPA expanded the NPDES Stormwater Program with the release of the Phase II Final Rule published in the Federal Register. This ruling required discharge permits for small MS4s (selection based on US Census data) and construction activities with 1-5 acres of soil disturbance. Erie County is listed with the EPA NPDES Stormwater Program as a Phase II community, however areas within the OWC watershed boundary are not considered urbanized by the 2000 Census and therefore is not included in the Erie County Phase II plan. Construction activities where the development plans disturbance of one acre or more within the OWC watershed do require NPDES Phase II permits.

Pollution control expectations center on implementation of programs and practices to control polluted storm water runoff through the use of NPDES permits. The Phase II program approach attempts, among other things, to facilitate and promote watershed planning and to implement the storm water program on a watershed basis (USEPA, 2000). Storm water management, therefore, will play an increasingly important role in both the planning and implementation of watershed action plans that aim to remediate impaired waterbodies.

Section 319 also serves as a significant source of federal funding, channeled through the states, for programs (e.g. BMP adoptions) that are designed to reduce nonpoint source pollution. State-endorsed Watershed Action Plans are currently an eligibility criteria/requirement for Section 319 funding in Ohio. Pollution reduction strategies outlined in Chapter 6 are designed to facilitate application for and approval of future Section 319 grants.

Safe Drinking Water Act (SDWA)

The SDWA created a federal program to monitor and improve the safety of the nation's drinking water supply. The SDWA authorizes the USEPA to set and implement drinking water standards to protect against both naturally occurring and man-made contaminants in public drinking water. The roots of Ohio's Source Water Protection Plan, a program to assist public water suppliers in protecting their sources of drinking water (streams and aquifers) from contamination, can be traced back to the SDWA.

Ohio's Source Water Protection Program addresses only public water systems and features two phases. The first phase is an assessment phase which involves delineating the area in need of protection, identifying the potential contaminant sources in that area, and determining the susceptibility of the drinking water source(s) to potential pollution. The OEPA reported that this phase was better than 99% complete for Ohio's community public water systems by January 2004. The second phase, just getting underway, involves developing and implementing a local drinking water source protection plan. This second phase is led by the public water system owner/operator with assistance from others, including local watershed groups. It makes sense that these source water protection plans be integrated into watershed action plans as both strive to protect the vital water resources necessary for human health, ecosystem health, and a healthy economy.

In the OWC watershed, water is provided to residents and businesses through Erie County Department of Environmental Services and Northern Ohio Rural Water. Both agencies distribute water purchased from the cities of Sandusky, Huron, and Vermilion, whose source water is taken directly from Lake Erie. Although the Safe Drinking Water Act may act as a key driver of watershed planning efforts, this act is not directly tied to the OWC watershed due to the absence of a source water intake within its boundaries.

Coastal Zone Management Act (CZMA)

The Coastal Zone Management Act of 1972 (Public Law 92-583) established a voluntary national program within the Department of Commerce to encourage coastal states, including the Great Lakes, thus Ohio, to both develop and implement coastal zone management plans. This policy represents a unique federal-state partnership and was developed for conserving the nation's high-value coastal resources for present and future generations.

As part of the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA), Congress created a stand-alone provision to recognize the impacts of nonpoint source pollution on coastal water quality. Named after its placement within these amendments, Section 6217 requires that states and territories with approved coastal management programs develop a Coastal Nonpoint Pollution Control Program

(CNPCP). The Ohio CNPCP is administered by the ODNR Division of Soil and Water Conservation.

The CNPCP must be submitted to USEPA and the National Oceanic and Atmospheric Administration (NOAA) for approval and be implemented through the existing state coastal management program and the new nonpoint source management program that stems from Section 319 of the CWA. Within these state programs, management measures must be specified for restoring and protecting coastal waters from specific categories of nonpoint source pollution.

Management measures are defined in Section 6217 of the CZARA as “economically achievable measures for the control of the addition of pollutants from existing and new categories and classes of nonpoint sources of pollution, which reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint pollution control practices, technologies, processes, siting criteria, operating methods, or other alternatives.” Watershed Action Plans developed for the Ohio Lake Erie Basin must describe how the relevant management measures of the Ohio CNPCP will be implemented within the specific watershed if a watershed inventory or identified water quality impairments indicate applicability. Management measures must also be addressed in order for the State of Ohio to gain approval for its Coastal Nonpoint Source Pollution Control Program.

In addition to the CNPCP, The Coastal Zone Management Act stipulates that federal actions having reasonably foreseeable effects on any land or water use or natural resource of Ohio’s designated Coastal Management Area (sometimes referred to as the coastal zone) must be consistent with the enforceable policies of the Ohio Coastal Management Program. “Federal actions” include federal agency activities, federal license or permit activities, and federal financial assistance to state and local governments. This “consistency” requirement is one of the greatest strengths of the CZMA.

Since the adoption of the Ohio Coastal Management Program in 1997, proposed projects have been reviewed by ODNR to determine whether they will be implemented in a manner that is consistent with the Ohio Coastal Management Program’s enforceable policies. These policies contain provisions that are legally binding under State law and are federally approved as part of the Ohio Coastal Management Program by NOAA. In Ohio, the coastal zone is defined in 9 coastal counties ranging up to 15 mile inland in the west (in low lying wetlands and floodplains) and 1/8 mile inland in the east where bluffs are adjacent to the shoreline. In OWC, the coastal zone reaches approximately one mile south of the OWC State Nature Preserve boundary to the Norfolk and Western railroad tracks (approximately 2.25 miles from the shoreline).

Section 315 of the CZMA established a system of field laboratories for conducting management-oriented research in estuaries around the country. The OWC National Estuarine Research Reserve (NERR) was established in 1980 at the OWC estuary, which is protected as an ODNR-managed state nature preserve. The NERR is operated as a state-federal partnership between the Ohio Department of Natural Resources-Division of Wildlife (DOW) and NOAA. The Reserve's mission is to improve the understanding and stewardship of lower Great Lakes estuaries, coastal wetlands, and their watersheds.

The majority of previous studies at OWC NERR have centered on the estuary, but several projects have taken a watershed scale examination. The Reserve is required to create a management plan for approval by NOAA that establishes priorities for the integrated research, education, and stewardship functions of the Reserve.

The Reserve's 2009-2013 management plan identifies non-point source pollution as a critical issue that must be addressed to ensure the sustainability of the estuary. The plan acknowledges the need to take a holistic ecosystem-based approach in managing the estuary. The plan makes collaboration with local watershed-scale planning and management efforts a high priority during upcoming five years.

The OWC NERR Land Conservation strategy was written in 2006 with a primary and a secondary purpose in mind. The primary purpose is to serve as a guide for future conservation activities in the OWC watershed by the OWC NERR and to influence land conservation activities undertaken by other public and private organizations within the watershed. The second purpose is to highlight OWC NERR's conservation focus for potential funding sources. The plan establishes an area of high conservation interest for the Reserve and a Stewardship focus corridor along the stream's tributaries. (Figure 15) OWC NERR would seek funding to conserve priority parcels when willing sellers are identified.

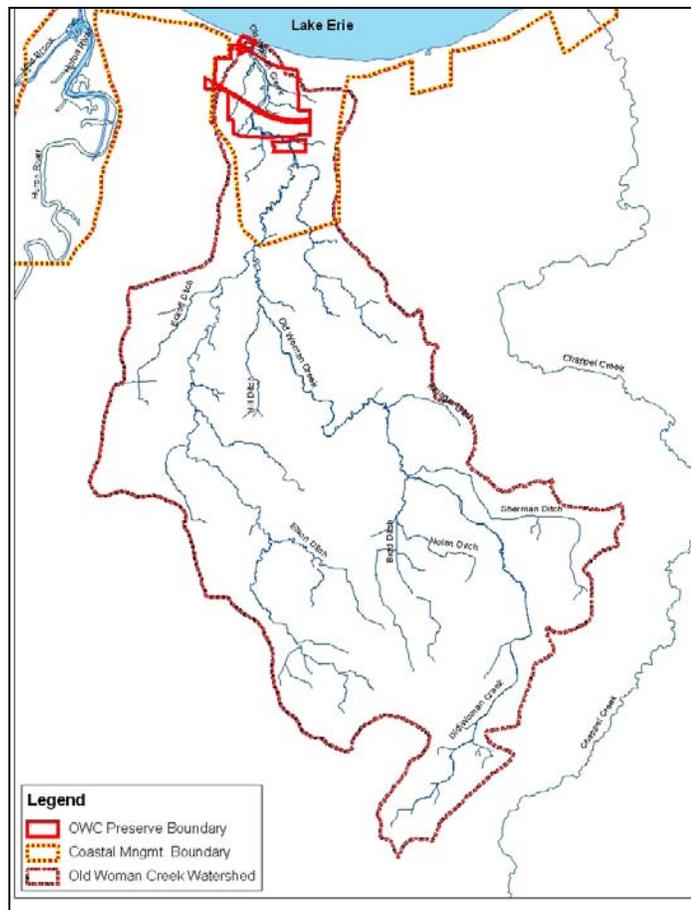


Figure 14: Coastal Zone Management Area (blue hatched line) covering the Reserve boundary of Old Woman Creek. (Ohio Coastal Atlas online mapper, 2008).

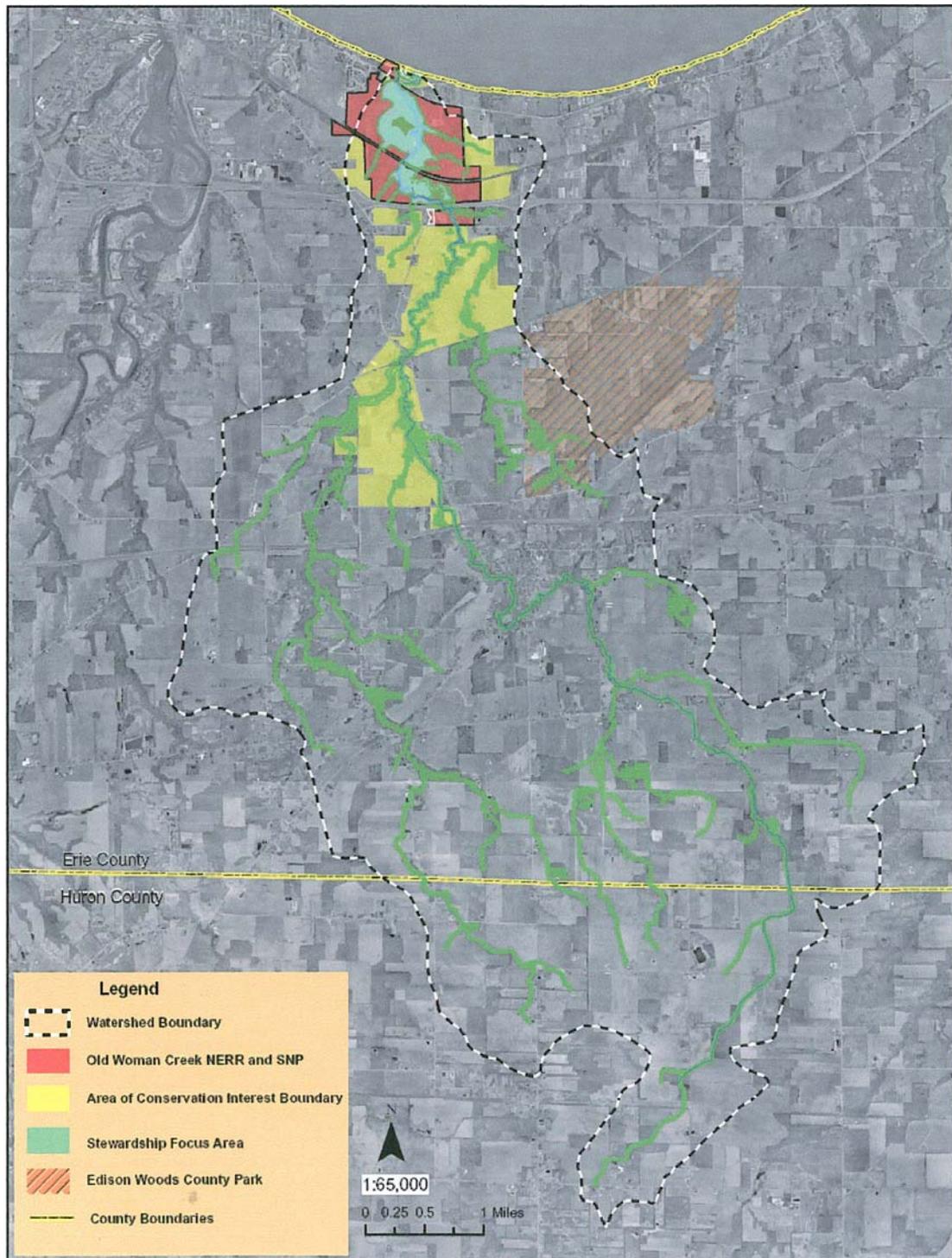


Figure 15: Old Woman Creek (Core Area), Area of Conservation Interest, and Stewardship Focus Area. (OWC NERR Land Conservation Strategy, 2006)

Ohio Nonpoint Source (NPS) Management Plan

The State of Ohio's new Nonpoint Source (NPS) Management Plan 2005 – 2010 was approved by the USEPA on August 29, 2006. The previous comprehensive Ohio NPS Management Plan was developed in 1988 and guided by the CWA Amendments of 1987. This plan was appended in 1993 and 1998.

Ohio's Nonpoint Source Management Plan focuses on four main topics: Targets, Planning, Solutions, Funding. The development and implementation of Watershed Action Plans is a key ingredient of state NPS management plan and include all five priorities of the management plan with a localized focus on planning and implementation efforts. Watershed Action Plans are to provide science-based, community-led, and sustainable efforts.

Lake Erie Protection & Restoration Plan (LEPR)

While neither a law nor regulatory mechanism, the Lake Erie Protection & Restoration Plan is nonetheless the State of Ohio's blueprint for Lake Erie's future. It serves as a guidance document for achieving the goals and objectives set forth in a companion piece, the Lake Erie Quality Index (LEQI) < <http://www.epa.state.oh.us/oleo/reports/leqi/leqi2004/leqiz.htm> >. Because of its location within the larger Lake Erie watershed, land use activities within OWC have a direct impact on Lake Erie.



Figure 16: Kelley's Island on Lake Erie. (ESWCD)

The Ohio Lake Erie Commission was established to preserve Lake Erie's natural resources, protecting the quality of its waters and ecosystem, and promote economic development in the region. The director of the Ohio Department of Natural Resources currently chairs the Commission which also includes directors of the state departments of Transportation, Health, Development, Agriculture and the Ohio Environmental Protection Agency.

The *Lake Erie Protection & Restoration Plan 2008* (LEPR) was released in September 2008 and outlines actions the Ohio Lake Erie Commission and its member agencies will take toward the restoration Lake Erie and its watershed. The Commission previously highlighted remediation focus areas in the *Lake Erie Protection & Restoration Plan* released in 2000. The 2000 LEPR plan identified 84 action steps to protect and restore Lake Erie. After eight years, this plan needed to be significantly updated to reflect emerging issues, the changing Lake Erie ecosystem, as well as the unified Great Lakes approach embodied in the Great Lakes Regional Collaboration.

The *LEPR 2008* provides a road map for Ohio's efforts to protect and restore Lake Erie through 2014 and coordinates these actions through the Ohio Lake Erie Commission. The *LEPR 2008* focuses on 10 priorities including nine established by the Great Lakes Governors (nonpoint source pollution, invasive species, coastal health, areas of concern, toxic pollutants, habitat & species, indicators and information, sustainable development, water withdrawals) plus the emerging priority of climate change. The plan establishes goals for each priority, strategic objectives to be accomplished through 2014, and actions related to the strategic objectives for fiscal years 2009-2011. Periodic updates will be included along with the *Plan* at the Ohio Lake Erie Commission website: <http://lakeerie.ohio.gov>.

The Commission also oversees the Ohio Lake Erie Protection Fund, which is a source of grant money for projects that benefit the Lake Erie watershed economically and environmentally. This fund is supported by Ohioans who purchase Lake Erie license plates.

LEPR strategic objectives related to nonpoint source pollution include reducing agricultural sediment loading from the Lake Erie Watershed by 33% (from 2007 baseline), reestablishing more natural flow regimes in Lake Erie tributaries, and protect, restore, and enhance headwater streams. Actions related to these objectives include supporting existing programs such as the Lake Erie Conservation Reserve Enhancement Program and supporting implementation of Watershed Action Plans. These strategic objectives are compatible with the need to reestablish and reconnect riparian corridors/buffers in OWC, particularly in the east branch. Recommendations in this WAP that address the requirements of improving water quality in OWC will, therefore, augment the vision of the LEPR.

Lake Erie Lakewide Management Plan (LaMP)

The Lake Erie Lakewide Management Plan (LaMP) provides a structure for the people of the United States and Canada to address environmental and natural resource concerns, coordinate research activities, pool resources, and make joint commitments to improving the environmental quality of our shared resource: Lake Erie (Lake Erie LaMP Work Group, 2004). An excerpt from this binational effort clarifies why the Lake Erie LaMP, updated yearly, is relevant to the OWC watershed:

The environmental integrity of Lake Erie is dependent not only on various characteristics and stressors within the lake itself, but also on actions implemented throughout the Lake Erie watershed and beyond. Urban sprawl, shoreline development, climate change, the introduction of exotic species, the exploitation and destruction of natural lands and resources, the dominant agricultural and industrial practices within the lake basin, and long-range transport of contaminants from outside the basin all impact the health of Lake Erie.

The Lake Erie LaMP identified land use practices as the dominant issue affecting the Lake Erie ecosystem. For agricultural lands, the Lake Erie LaMP calls for continuing reductions in the use of conventional tillage and application of agricultural chemicals and fertilizers. Specific watershed targets will be established for securing, protecting, and restoring natural lands. Phosphorus exports from diffuse non-point sources, including agricultural land, will be greatly reduced to aid in the recovery and maintenance of healthy aquatic communities in Lake Erie tributary watersheds.

To learn more about the Lake Erie LaMP, readers are encouraged to visit this website: <http://www.epa.gov/glnpo/lakeerie/2004update/index.html>

Lake Erie Balanced Growth Program

The Lake Erie Balanced Growth Program of the Ohio Lake Erie Commission has produced a voluntary, incentive-based strategy to protect and restore Lake Erie and its watersheds, while achieving long-term economic competitiveness, improving ecological health, and quality of life. The planning framework recommends a voluntary, incentive-based program for balanced growth in the Ohio Lake Erie basin. This framework reflects ten guiding principles that are outlined in the LEPR discussed above.

Throughout the Balanced Growth planning framework, a watershed approach is promoted for planning and decision-making. Furthermore, this framework includes active roles for both local and state governments in supporting local watershed planning partnerships. The essence of the Balanced Growth framework is fully compatible with watershed action plans developed at the scale of OWC. Implementation of the Lake Erie Balanced Growth Program has made progress on several fronts:

- Four pilot watersheds are currently developing Watershed Balanced Growth Plans which are a regional framework for coordinated, local decision making about how growth and conservation should be promoted by local and state policies and investments.
- A State Balanced Growth Incentives Strategy identifies programs and policies that state agencies can use to assist and encourage local governments in implementing the Watershed Balanced Growth Plans.
- The Commission sponsors an awareness and training program on Best Local Land Use Practices highlighting model regulations and local guidance.



Figure 17: Farmland in Erie County being converted to residential development. (FSWCD)

To learn more about Balanced Growth in the Ohio Lake Erie Watershed, please visit the following website: <http://www.lakeerie.ohio.gov/BalancedGrowth.aspx>

Ohio Household Sewage Treatment Regulations

Effective May 6, 2005 Substitute House Bill 231 (125th General Assembly) Chapter 3718 of the Ohio Revised Code became law required the Public Health Council to adopt new rules governing household sewage treatment systems and small flow on-site sewage treatment systems (not more than 1,000 gallons of sewage per day).

In May 2006 according to this law and as revised in Chapter 3701-29 of the Ohio Administrative Code (OAC), the Council adopted new sewage treatment system (STS) rules which became effective January 1, 2007. The new regulations give the Ohio Department of Health statutory authority to provide oversight, support and review of the new STS rules. The new regulations affect new and replacement systems permitted after January 1, 2007. Several system design options are available and tailored to the site based on both soil and site conditions, with options for sites with perched seasonal high water tables.

The OAC 3701-29 provides rules for NPDES permit requirements to address future discharges from a limited number of new and replacement HSTS that may be needed on sites where treatment in the soil is not feasible. The STS rules provide a means of compliance to the Clean Water Act requirements for household system discharges.

The STS rules include requirements for the operation and maintenance of HSTS as well as the management of STS residuals and the collection, transportation, disposal and land application of domestic sewage. The new STS rules will be comprehensively reviewed in three years in order to identify and resolve issues or challenges presented by the current rule language. Immediate concerns will be addressed prior to this comprehensive review period.

Erie Regional Planning Commission

The Erie Regional Planning Commission (ERPC) has the responsibility to review and require proposed land subdivision and require them to comply with reasonable standards for development in the unincorporated areas of Erie County. These requirements are provided in the Erie County Subdivision Regulations as adopted October 7, 2004. Development is also reviewed in accordance with the Erie County Comprehensive Plan. The Commission has developed and revised these regulations to provide a minimum set of procedures, standards and specifications to achieve the goals and purposes of Erie County. It is in the best interests for both the County and private enterprise that every subdivision is well-designed and constructed; that every subdivision results in ordered growth; stable environments; and desirable, livable communities for the benefit of all citizens.

Included in these regulations are provisions for orderly development, responsible natural resource management, adequate health requirements, and adequate open-space, cultural, recreational and educational facilities.

As the authority is granted by Ohio Revised Code Chapter 711 to the Board of County Commissioners and the ERPC to adopt and enforce these regulations, the result is valuable to the citizens and future land use in the unincorporated areas of the OWC Watershed. These regulations will be used in conjunction with the local township zoning regulations to insure proper development standards are met.

This document can be downloaded in its entirety from the Erie Regional Planning Commission website at <http://www.erie-county-ohio.net/planning/planning.htm>

Erie County Floodplain Regulations

The revision to the Erie County Floodplain Regulations, adopted July 3, 2008, effective August 3, 2008, was in response to an update of the *Flood Insurance Study Erie County, Ohio and Incorporated Areas* and *Flood Insurance Rate Map Erie County, Ohio and Incorporated Areas* both effective August 28, 2008.

The purposes of the floodplain regulations include:

- protection of human life and health
- minimizing costly flood control projects
- minimizing prolonged business interruptions
- maintaining a stable tax base by providing for the proper use of areas of special flood hazard
- ensuring that those who occupy the areas of special flood hazard assume responsibility for their actions
- minimizing the impact of development on adjacent properties within and near flood prone areas
- ensuring that the flood storage and conveyance functions of the floodplain are maintained
- minimizing the impact of development on the natural, beneficial values of the floodplain
- preventing floodplain uses that are either hazardous or environmentally incompatible, and,
- meeting community participation requirements of the National Flood Insurance Program.

Some of the methods included in the plan to reduce flood loss are by restricting uses that cause damaging increases in flood heights or velocities; by controlling the alteration of natural floodplains, stream channels, and natural protective barriers; by controlling filling, grading, dredging, excavating, and other development which may increase flood damage; and by regulating the construction of flood barriers, which will unnaturally divert floodwaters which may increase flood hazards in other areas.

These regulations have been adopted for the unincorporated areas of Erie County, including unincorporated areas of the OWC Watershed. Many of the methods included in these regulations align with the recommendations provided within this WAP document to achieve or maintain a healthy watershed.

This document can be downloaded in its entirety from the Erie Regional Planning Commission website at <http://www.erie-county-ohio.net/planning/planning.htm>

Erie County Stormwater Regulations

Revised October 2008, The Erie County Stormwater Management Regulations have been adopted by the Board of the Erie County Commissioners to provide information to the public and development community on stormwater policy and design practices and to assist developers, engineers, public officials, and county staff in the review and approval of development proposals. The purpose of the regulations is to establish feasible and economically reasonable standards for management and conservation practices to prevent flooding, streambank erosion, and water quality degradation that may result from stormwater runoff in conjunction with urban earth-disturbing activities.

More specifically, the regulations intend to permit development without increasing downstream flooding, erosion or sedimentation; reduce damage to receiving streams and impairment of their capacity; reduce negative impacts to receiving streams and impairment of their Ohio EPA designated uses of water quality goals as stated in an approved TMDL report; and establish a basis for the design of all storm drainage systems and water quality best management practices.

These regulations are applicable to development and redevelopment activity within the unincorporated areas of Erie County. Through cooperative agreements and legislative action, other local units of government could use the provisions of these regulations.

For more information, these regulations can be accessed at <http://www.erie-county-ohio.net/engineer/regulations.htm>.

Huron County Planning Commission

Effective January 1, 2009, the Huron County Subdivision Regulations will allow the Huron Soil and Water Conservation District (Huron SWCD) through an agreement with the Board of Huron County Commissioners to review and enforce the provisions of the regulations and the recommendations contained within the Huron County Comprehensive Land Use Plan.

These regulations are intended to provide for the public health, safety, and welfare; ensure subdivided land can be used for its intended purpose; provide for orderly, beneficial development in accordance with adopted plans; prevent pollution of the environment; and promote consideration of sustainability of the natural environment including natural resources including prime agricultural soils.

As the authority is granted by Ohio Revised Code Chapters 711 and 713 to the Board of County Commissioners to adopt and assign enforcement of these regulations, the result is valuable to the citizens and future land use in the unincorporated areas of the OWC watershed. These regulations will be used to insure proper development standards are met.

For more information and to access the Huron County Subdivision Regulations you can access the “*Planning Commission*” section of the Huron SWCD website, <http://www.huronswcd.com>.

Additional rules and regulations may be adopted in support of the Subdivision Regulations, including but not limited to storm water management regulations, flood damage reduction regulations, access management policies, water quality regulations, health and environmental protection regulations, and erosion and sedimentation controls.

Farm Bill Programs

This first farm bill was in effect after the Agricultural Adjustment Act of 1933 which was set to aid in regulation of crop production prices. In 1935 The Soil Conservation Act was passed which provided for funding of soil conservation practices being used in crop production. It wasn't until the 1980s that the conservation programs expanded to encompass natural resource conservation as well as soil erosion reduction. In the 1985 Farm Bill, Highly Erodible Land Conservation (“Sodbuster”), Wetland Conservation (“Swampbuster”), and Conservation Reserve Programs were introduced to protect lands more vulnerable to soil loss and provided protection of wetland areas at risk of being converted to crop production. The 2008 Farm Bill has several conservation programs for protecting our natural resources including: wetland creation and protection, pasture management, manure storage, nutrient management, tillage practices, wildlife enhancements, and erosion control. In the OWC watershed, three programs are currently being utilized by producers: Conservation Reserve Program (CRP), Environmental Quality Incentives Program (EQIP), and Conservation Security Program (CSP).



Figure 18: CREP filter strip (ESWCD)

Conservation Reserve Program (CRP). This program was designed to transfer highly erodible land from crop production to conservation status. This program provides annual rental payments based on the length of the agreement and cost shares up to 50% to assist with conversion of land to less intensive use. The requirements of the producer are to develop and implement a plan for land

conversion, agree to a term of 10-15 years for the practice, and meet land eligibility requirement of the program.

Environmental Quality Incentive Program (EQIP). This program was designed to mitigate environmental problems associated with farming operations. This program has been used to assist with livestock waste facilities, stream fencing, livestock crossing, waterways, and wildlife habitats. The cost share provided by this program is up to 75% for a period of 1-10 years. All private land in agricultural production is eligible if the producer agrees to develop and follow an EQIP plan that describes the conservation practices and environmental benefits to be achieved.

Conservation Stewardship Program (CSP- Formerly Conservation Security Program). This program was designed to provide incentives to producers that have implemented various conservation practices in their farm operation based on the number of environmental concerns resolved. The CSP provides annual payments based on the length of the agreement and the level qualified by the producers' conservation practices (total of three tiers). To qualify, the producer must have land incorporated into farming operations, agree to a 5-10 year length of agreement, and install/maintain conservation practices on working lands.

Lake Erie Conservation Reserve Enhancement Program (CREP). In 2000, Ohio began the first CREP program in the Lake Erie watershed. This program was designed to compensate producers for the installation of various conservation



Figure 19: CREP wetland. (ESWCD)

practices (buffer strips, riparian buffer, wildlife habitat, wetlands and windbreaks) in place of crop production on environmentally sensitive land in the Lake Erie watershed. The program offers rental payments and cost-share for installation of conservation practices as well as bonus payments for select practices. To qualify, the producer must have land located in the Lake Erie watershed and meet commodity requirements set by NRCS, and agree to a 15 year agreement.

Agriculture Pollution Abatement Program

Ohio's Agricultural Pollution Abatement Program (APAP) may provide farmers with cost share assistance to develop and implement best management practices (BMP) to protect Ohio's streams, creeks, and rivers. This program has been successful in helping to alleviate concerns associated with agricultural production and silvicultural operations which can create soil erosion and manure runoff. Nonpoint source (NPS) pollution occurs when precipitation picks up contaminants and carries them to a watercourse. The APAP is administered by Ohio Department of Natural Resources-

Division of Soil and Water Conservation and implemented locally by all 88 Soil and Water Conservation Districts. Dependent upon the BMP being installed, the program offers 75% cost share in three levels of funding caps ranging from \$5,000 to \$15,000. Practices eligible for funding through this program focus on resolving natural resource concerns related to livestock operations.

ODNR-Division of Wildlife - Strategic Plan

The ODNR Division of Wildlife (DOW) administers the OWC NERR and is a key stakeholder agency in watershed conservation efforts. The DOW is the state agency responsible for management of Ohio's fish and wildlife resources. The Division operates under a broad set of authorities granted in the Ohio Revised Code. A portion of the Revised Code states that the DOW holds title to all wild animals, which are not legally confined or held in private ownership, in trust for the benefit of all Ohioans. The Revised Code further directs the Division to plan, develop, and institute programs and policies that are designed for the general care, protection, and supervision of wildlife resource in the state. The Division is also empowered to develop and enforce regulations for the protection, reservation, propagation, management, and wise use of wildlife and specific plants.

The Division's Strategic Plan for 2001-2010 establishes a goal relating to streams and watersheds to "increase the knowledge Ohioans have about streams and watersheds." The plan goes on to highlight conservation, monitoring, education, and research actions that should be taken to create the highest quality stream habitats for the state's fish and wildlife resources.

Chapter 4. Old Woman Creek Watershed Inventory

Purpose

In this chapter, the reader will find detailed information about the watershed including its geology, biology, land use, cultural history, current demographics, and background on historical and present day watershed stewardship efforts completed by partnering agencies of the FCT. This chapter is designed to be a resource for education and future funding opportunities. Information found within the chapter also served in part as the driving force behind the creation of the FCT and the development of implementation strategies described in Chapter 6.

Chapter Acknowledgements

This chapter was prepared using material from *The Ecology of Old Woman Creek, Ohio: An Estuarine and Watershed Profile* by permission, submissions by members of the WAP workgroup, and inventory and research completed by the watershed coordinator and the FCT partners.

GEOLOGY

TOPOGRAPHY & LANDFORMS

Basin Topography. Old Woman Creek drains 27 square miles of primarily agricultural land (Figure 20). The headwater tributaries of OWC originate on the glacial till plain surface at an elevation of approximately 885 feet above sea level. Two main branches of OWC, east and west, originate in the till plain, cut independently through a sandstone escarpment, and join on the lake plain about 1.5 miles south of an estuary, which forms the mouth of the creek (Herdendorf et al. 2004, 2006).

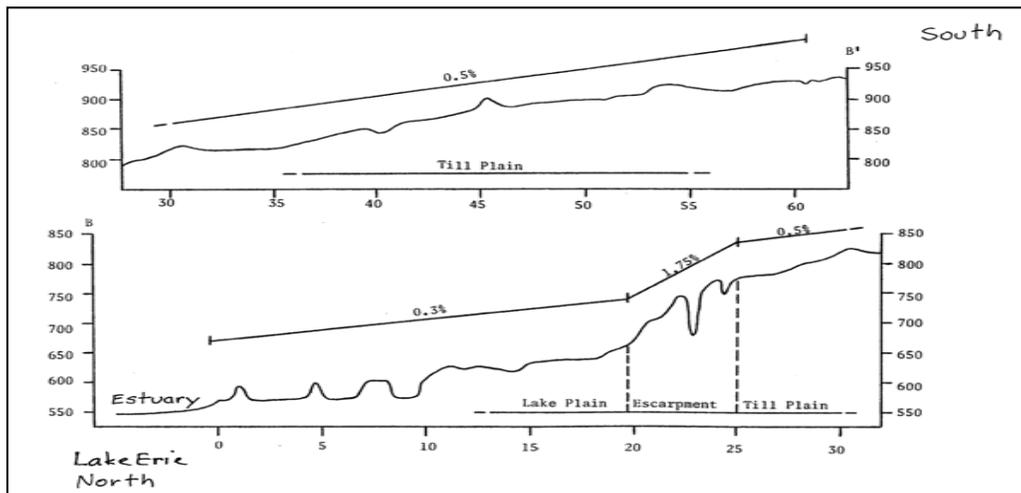


Figure 20: Topographic profile across the Old Woman Creek watershed. (horizontal scale in thousands of feet.)

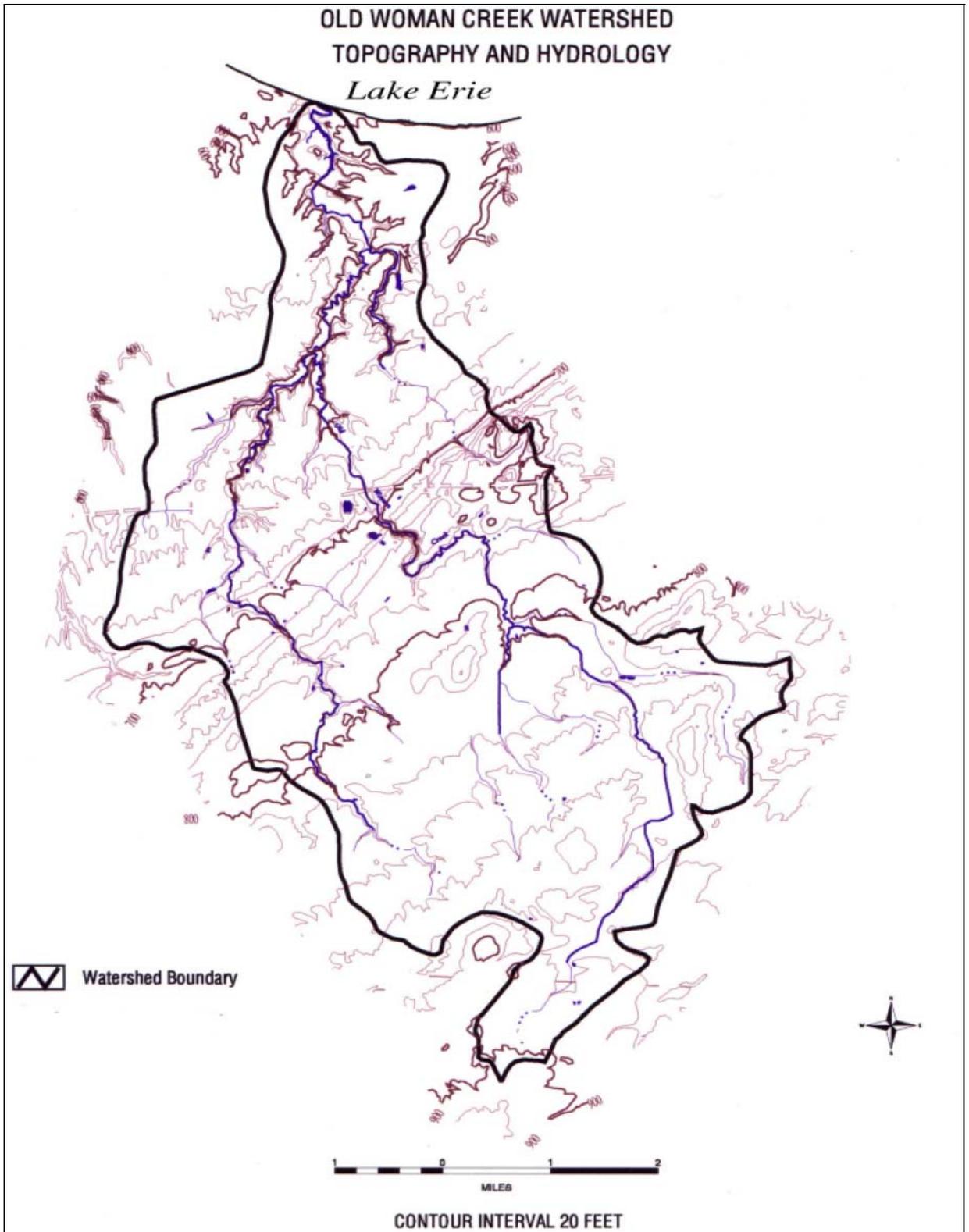


Figure 21: Surface drainage pattern of Old Woman Creek Watershed, Herdendorf, et al. 2004.

Horton (1945), as modified by Strahler (1952), developed the stream order method of analyzing the bifurcations of a stream and comparing the complexity of one watershed to another. In this method each headwater or fingertip tributary (including ephemeral and intermittent streams) is designated as the first order. Two first-order tributaries combine to produce a second-order tributary, two second-order tributaries produce a third, and so on. Only the union of two tributaries of equal order can produce a higher order, thus the order of the trunk stream is not changed below the confluence with a stream of lower order. Generally, the diversity and abundance of aquatic organisms in a stream increases as its order increases. Both the east and west branches of OWC are third order stream, thus 1.5 miles above, and within, its estuary, OWC is a fourth-order tributary to Lake Erie. The total length of all the tributaries in the watershed is approximately 47 miles, 27 miles of which are associated with the east branch, 15 miles with the west branch, and 5 miles with the main stem and estuary below the confluence.

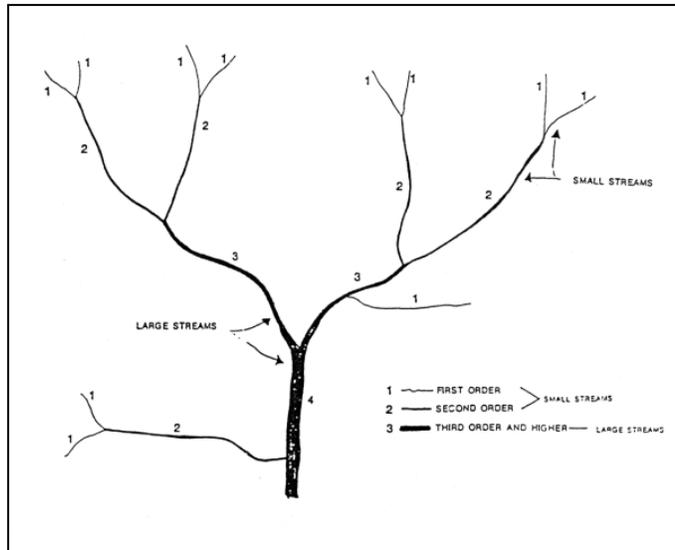


Figure 22: Stream order hierarchy.
Source: www.stormwatercenter.net

Generally, the diversity and abundance of aquatic organisms in a stream increases as its order increases. Both the east and west branches of OWC are third order stream, thus 1.5 miles above, and within, its estuary, OWC is a fourth-order tributary to Lake Erie. The total length of all the tributaries in the watershed is approximately 47 miles, 27 miles of which are associated with the east branch, 15 miles with the west branch, and 5 miles with the main stem and estuary below the confluence.

Table 2. Stream orders for OWC watershed.

| ENTIRE WATERSHED | | | |
|---------------------|-----------|---------------------|----------------------|
| ORDER | NUMBER | MEAN LENGTH (miles) | TOTAL LENGTH (miles) |
| 1 st | 28 | 0.9 | 26.1 |
| 2 nd | 6 | 1.9 | 11.3 |
| 3 rd | 2 | 3.0 | 5.9 |
| 4 th | <u>1</u> | <u>3.3</u> | <u>3.3</u> |
| Total | 37 | 1.2 | 46.6 |
| WEST BRANCH | | | |
| 1 st | 13 | 0.5 | 6.8 |
| 2 nd | 3 | 2.4 | 7.1 |
| 3 rd | 1 | 1.2 | 1.2 |
| EAST BRANCH | | | |
| 1 st | 11 | 1.6 | 17.5 |
| 2 nd | 3 | 1.4 | 4.2 |
| 3 rd | 1 | 4.7 | 4.7 |
| MAIN STEM & ESTUARY | | | |
| 1 st | 4 | 0.5 | 1.8 |
| 4 th | 1 | 3.3 | 3.3 |

The boundaries of the drainage sub-basins within the watershed were determined from surface features (topographic divides) depicted on USGS topographic maps, soils maps, and aerial photographs. With a total surface drainage area of 27 square miles and a total stream length of 47 miles, drainage density for the watershed (total stream length/area of drainage basin) is 1.7 miles/square mile.

OWC empties into Lake Erie at an elevation of 572 feet, about 15 miles downstream of its headwaters. Thus, the creek drops 313 feet yielding an average gradient of 21 feet/mile or 0.40% (Buchanan 1982). However, the overall gradient is more properly understood when the creek valley is divided into three distinct geomorphic reaches: (1) till plain, (2) Berea Escarpment, and (3) lake plain (Figure 4.2). The characteristics of these reaches are more fully described below in the Landform section of this inventory.

The channel of OWC as it passes through the till plain drops from an elevation of 885 to 750 feet. The average gradient for this 7.5-mile section is 18 feet/mile or 0.34 %. The stream gradient is less steep than that of the surface topography of the till plain because of the effects of channel cutting into the till surface. The heights of valley walls in this section range from nil at the headwaters to 25 feet near Berlinville. The dendritic stream pattern of OWC in the till plain is classified as being in a “late youthful” development stage (Buchanan 1982) in .

At an elevation of 750 feet, significant exposures of bedrock appear in the creek valley and continue to an elevation of 610 feet as the creek traverses the 2.3 miles of the Berea Escarpment. The stream gradient for this section is 61 feet/mile or 1.15%. The erosion of deep gorges and ravines in the bedrock of the escarpment has also reduced the stream gradient below the gradient of the surface topography. The gorges in this section have valley walls up to 90 feet high. The dendritic stream pattern of OWC shows some rectangular influences within the rock exposures of the escarpment and is classified as being in a “youthful” development stage (Buchanan 1982).



Figure 23: Village of Berlin Heights Gorge, east branch Old Woman Creek. (Hohman)

Below an elevation of 610 feet and on to its mouth, a distance of 5.4 miles, OWC traverses the lake plain. The stream gradient in this section is only 7 feet/mile or 0.13%, although the lacustrine sediments in the section are easily eroded yielding some deep channels. The wide floodplain, U-shaped valley, and meandering pattern

of the creek all reflect a “mature” stage of stream development (Buchanan 1982). The heights of valley walls in this section range from 25 to 40 feet.

Landforms. Several notable landforms or geomorphic features occur within the environs of OWC watershed. Progressing in a general way from north to south they include: (1) Lake Erie, (2) lakeshore barrier beach, (3) OWC estuary, (4) Star Island, (5) lake plain, (6) abandoned glacial-lake beach ridges, (7) Berea Escarpment, (8) Berlin Heights ravine, (9) glacial till plain, and (10) the valley of OWC which traverses the entire area from south to north. A general description of each of these landforms follows.

Lake Erie. Old Woman Creek empties into the central basin of Lake Erie along the Ohio shore at Lat. 41°23'04" N and Long. 82°31'20" W. Lake Erie is one of the largest freshwater lakes in the world, ranking 9th by area and 15th by volume, with a surface area of 15,942 square miles, maximum depth of 210 feet, and a volume of 115 cubic miles (Herdendorf 1982). Erie is the southernmost of the North American Great Lakes, geologically the oldest, and by far the shallowest with its entire water mass lying above sea level. Lake Erie is a relatively narrow lake, 240 miles long by 57 miles wide, with its long axis oriented southwest-northeast. This axis parallels the prevailing wind direction which causes the lake to react violently to storms, causing the production of high waves and wide fluctuations in water level.



Figure 24: Lake Erie at shores of Old Woman Creek watershed. (Hohman)



Figure 25: Barrier beach at the mouth of Old Woman Creek estuary. (Herdendorf)

Barrier Beach. The junction of OWC and Lake Erie is marked by a barrier beach which separates the lake from the estuary. Based on 1956 aerial photographs, Herdendorf (1963a) reported that 1,700-foot-long beach extended 900 feet to the west and 800 feet to the east of the creek mouth; the beach was nearly 200 feet wide near its center and tapered to 50 feet wide at the ends. Sand dunes, 3 to 6 feet in height, that had formed along the eastern half of the beach were actively being cut by wave action as the bar migrated landward at a rate of about 3 feet/year. Herdendorf

(1963a) further observed that the creek mouth was normally barred across, being open only during periods of heavy rainfall and high water levels. In 1990, the barrier beach was about 1,400 feet long and ranged from 275 to 45 feet wide.

Starting in 1983, daily records have been kept of the conditions at the mouth of the estuary, especially whether the barrier bar was open or closed. Herdendorf and Hume (1991) reported that during the 8-year period 1983-1990 the inlet was open 59% and closed 41% of the time, but annual percentages ranged from about 30% to 70% for each condition.

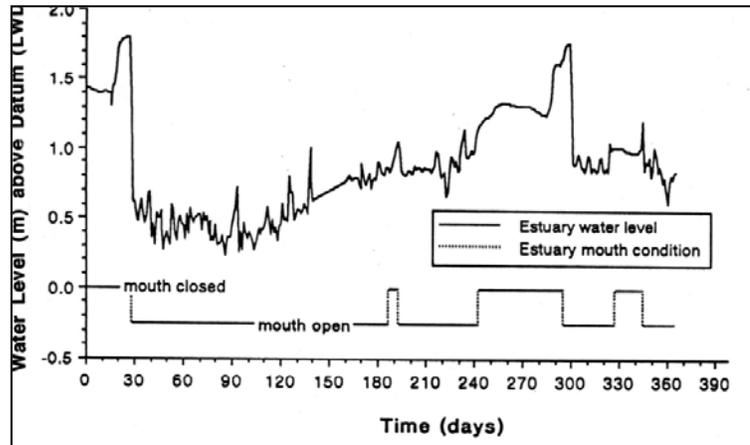


Figure 26: Water levels in Old Woman Creek estuary showing open/closed condition of inlet for water year 1990 (October 1989 to September 1990). (Herdendorf, et al. 2004)

Plots of mean daily water levels at the mouth show a marked seasonal trend

(Herdendorf et al. 2004, 2006). During summer months the estuary mouth is typically barred across. Late in the year, October to December, the water level in the estuary builds up to >5 feet above Low Water Datum (LWD) at which stage the barrier is usually breached. As the water level in the lake and estuary decline during the winter, the mouth once again bars across. By the spring, the water level in the estuary is again controlled by lake levels, as the mouth is usually open by this time. However, this generalized seasonal pattern is often subject to disruption by short-term meteorological conditions.



Figure 27: Aerial photographs of Old Woman Creek estuary showing inlet closed (top) and open (bottom). (Herdendorf, et al. 2004)

The rapid water rise in the estuary in the later part of the year appears to be the result of the damming-effect of the barrier bar; neither precipitation nor runoff are sufficient to totally account for the nearly 18 million cubic foot increase in the water stored in the estuary prior to the fall breach. Over-topping of the bar by lake waves is also believed to supply a sizable quantity of water to the estuary, particularly during northeast storms (Herdendorf and Hume 1991). When the bar breaches, a delta” forms into Lake Erie at the mouth of the inlet. Sand from the barrier is flushed into the lake through a narrow discharge channel and deposited when velocities

of the exiting water drop below the transport threshold, about 1 inch/second for medium-grained sand (Herdendorf 1975).

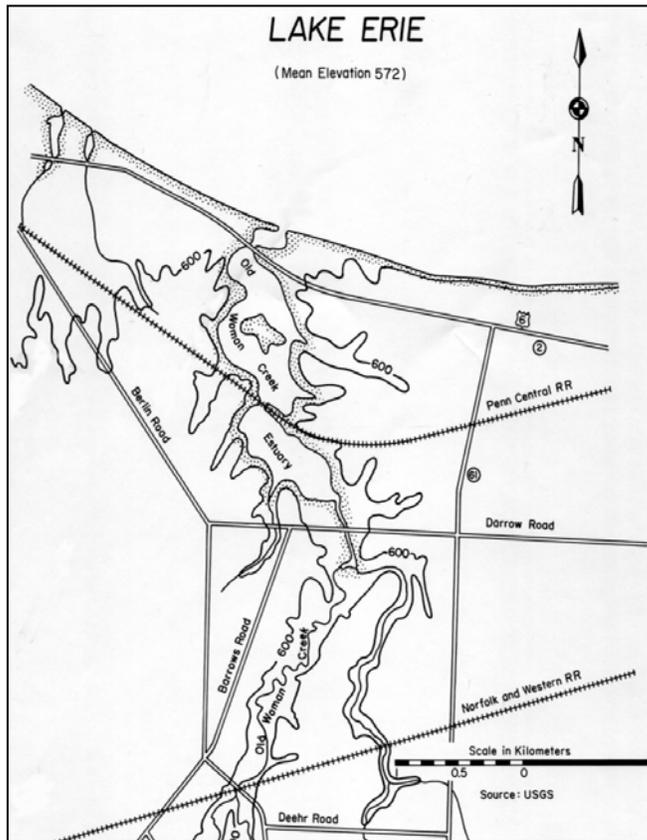


Figure 28: Lower reach of Old Woman Creek and its estuary in 1975. Elevation in feet above the mean sea level. (Herdendorf et al. 2004)

Old Woman Creek Estuary. The estuary comprises the lower 1.8 miles of the OWC. Examination of the bathymetric map prepared by Herdendorf and Hume (1991) reveals the estuary to be a broad, shallow basin that has been modified by manmade structures which tend to constrict and segment the stream's channels. Construction of the U.S. Route 6 bridge about 400 feet south of Lake Erie and the Conrail causeway and bridge another 0.75 miles to the south has resulted in estuary's segmentation into three sections: 1) lake lagoon, 2) main basin, and 3) south basin. An incised channel runs the entire length of the estuary and carries discharge waters directly into Lake Erie. When the water level in the estuary is standing at the mean level of Lake Erie (elev. 571.2 feet IGLD 1985 or +2 feet LWD) the average depth of the estuary is only 0.7 feet, the area of the estuary is 56 million cubic feet, and

the volume is 39 million cubic feet (Herdendorf and Hume 1991). The lake lagoon, main basin, and south basin, respectively, comprise 4%, 82%, and 14% of the total estuary area.

The lake lagoon is a small, elongated basin (east-west direction) that lies between U.S. Route 6 and the barrier beach that separates the estuary from Lake Erie. The outlet channel runs along the west side of the sub-basin. The beach area east of the outlet channel is known as Oberlin Beach. Aerial photographs taken over the past 60 years show that this basin was at one time more circular, when the barrier beach forming its north side was more than 300 feet farther



Figure 29: Aerial view of Old Woman Creek estuary. (Herdendorf et al. 2004)

lakeward. Recession of the shore, primarily the result of northeast storms, has taken place as waves overtopped the barrier bar and washed beach sand into the lagoon. Since 1937, the channel through the barrier bar has migrated from its present position to 600 feet farther east and back again where it remains permanent due to filling of the former outlet by the local beach association. The deepest portion of the basin occurs in the scour channel near the Route 6 bridge (-5 feet LWD). From the bridge to the lake the depth of the channel averages about -1 foot LWD.

The main section of the estuary is lacustrine-like and consists of a broad shallow basin that is cut by a narrow channel along its eastern margin and a secondary channel that splits off the main channel at the southern end of the basin and follows a course the west. The channels are shallow, generally with bottom elevations a few



Figure 30: American water lotus (*Nelumbo lutea*).
(Elmer)

tenths of a meter above LWD and only a few tenths of a meter below the surrounding bottom of the estuary (Herdendorf and Hume 1991). Star Island is located between these channels near the center of this basin. A natural levee, that is more persistent in the south basin, extends into the main basin as far north as Star Island. The main basin is surrounded by relatively

steep escarpments on all sides, including Star Island. Into the escarpments, on both sides but

particularly the east side, intermittent tributaries have cut several deeply entrenched, but shallow, coves. The majority of the basin has a floor elevation ranging from +1.3 to +2 feet LWD. This produces a depth that is particularly conducive for growth of dense beds of *Nelumbo lutea* (American water lotus). The highway and railroad constrictions at the north and south ends, respectively, of the basin are the deepest portions of the entire estuary. The channel at the Route 6 bridge is 60 feet wide and has a maximum depth of -6 feet LWD; whereas the channel at the Conrail bridge is 45 feet wide and has a maximum depth of -3 feet LWD.

The south basin of the estuary is more riverine-like and is comprised of a narrow channel that extends south from the Conrail bridge to the vicinity of the Darrow Road bridge. The channel is relatively deep (maximum -0.7 to -2.3 feet LWD) and flanked by natural levees along most of its course. A number of small, tributary-mouth lagoons are present along the estuary's west bank and an extensive lagoon and swamp forest is found along the east side of the estuary. This lagoon was a continuation of the main basin of the estuary, but it is now terminated on the north by the railroad causeway. The lagoon occupies an area with bottom elevations between +2 to +3 feet LWD, whereas the swamp forest occurs where the bottom elevation ranges from about +3 to +6 feet LWD. The deepest depths in the south basin occur in a narrow scour channel under the Conrail bridge (-2.3 feet LWD).



Figure 31: Aerial photo of Old Woman Creek estuary showing Star Island in center of estuary

Star Island. The valley of OWC within the estuary has two distinct channels between the Conrail and the Route 6 bridges resulting from a bifurcation about 500 feet north of the railroad. This bifurcation has preserved an isolated remnant of the lake plain known as Star Island around which the creek flowed to the east and to the west at various times (Buchanan 1982). The roughly star-shaped island now lies near the center of the estuary. The distance between its east and west points is about 1,500 feet and 900 feet between its north and south points. The sides of the island rise rather steeply to a flat top about 30 feet above the mean water level of the estuary. The entire island comprises an

area of 11 acres and its flat top has an area of about 2 acres. Star Island is the only island in the estuary with an elevation significantly above that of the water surface.

The erosional, rather than depositional, origin of Star Island has been inferred from the accordant height of the island with the surrounding uplands and the from the largely undisturbed lake plain sediments on the island's surface (Buchanan 1982). The soil types of the island, Sisson silt loam and Tuscola loamy fine sand, also match those of the surrounding upland areas of the lake plain (Redmond et al. 1971). These soils formed in stratified limy silt and very fine sand that was deposited on the bottom of glacial lakes with levels higher than modern Lake Erie.

Lake Plain. A band of relatively flat land paralleling the Lake Erie shore and extending inland approximately three miles on the east side of the OWC and six miles inland on the west side is known as the lake plain. It is a nearly level to gently undulating plain broken only by the steep-sided valleys of the two main branches of the creek and several abandoned beach ridges. The surface topography of the lake plain slopes lakeward at an average of 10.5 feet/mile or 0.2% (Buchanan 1982). The lake plain is terminated to the south by the steeply rising Berea Escarpment.



Figure 32: Aerial view of lake plain soils in Old Woman Creek valley immediately upstream of the estuary. (Feix)

The plain was covered by the waters of several glacial lakes that once occupied the Lake Erie basin. Conspicuous sand and gravel ridges, 10 to 20 feet above the plain and 100 to 200 feet wide, mark the former shorelines of these lakes (Herdendorf 1963b). The sediments deposited in these lakes form the surface material of the plain. These glaciolacustrine deposits consist largely of interlaminated clay, silt, and fine sand that overlie glacial till (Carter and Guy 1980). Generally, the soils of the lake plain mirror the underlying glaciolacustrine parent material. Lenawee-Del Ray association soils have formed on deposits rich in clay and silt; whereas deposits containing more silt and fine sand have produced soils of the Kibbie-Tuscola-Colwood and the Sission-Tuscola associations (Redmond et al. 1971).

Abandoned Beach Ridges. Several stages of six glacial lakes covered the lake plain with water depths 50 to 230 feet higher than modern Lake Erie. These included lakes Maumee, Arkona, Whittlesey, Wayne, Warren, and Lundy. The abandoned,



Figure 33: Wave-etched sandstone cliff of glacial Lake Maumee near crest of Berea escarpment at Berlin Heights, Ohio (Herdendorf et al 2004)

sandy beaches of these lakes form a series of more or less parallel ridges trending northeast-southwest at the southern edge of the lake plain (Carney 1911). The topographic profile of this part of the watershed is that of successively lower lake-plain terraces with a several-meter-high beach ridge and sand dunes at their southern terminus (Herdendorf 1963b). The major ridges (Maumee, Whittlesey, and Warren) are confined to a 1-mile-wide belt because of the rather rapid rise in the land surface at the southern edge of the lake plain as the plain merges with the Berea Escarpment. Where the

ancient shorelines coincided with outcrops of Berea Sandstone, wave-cut, headland features such as vertical cliffs, overhangs, arches, and caves were produced.

Berea Escarpment. This prominent escarpment is an erosional feature that follows the northern outcrop edge of the Berea Sandstone. Because this sandstone formation is the most erosion-resistant bedrock formation exposed in the watershed, erosion has left it standing well above the surrounding shale beds. This is especially the case in the vicinity of Berlin Heights where the escarpment occurs as a nearly two-mile-wide band that extends in a northeast-southwest direction between the Huron and Vermilion Rivers. Impressive rock gorges have been cut through the escarpment by the east and west branches of OWC and by nearby Chappel Creek. The surface topography of the escarpment slopes lakeward at an average of 94

feet/mile or 1.8% (Buchanan 1982). The local relief of the escarpment near Berlin Heights approaches 200 m.

The base of the escarpment lies at an elevation of about 650 feet and rises to a maximum elevation 850 feet northeast of Berlin Heights. The steepness of the escarpment's north slope is governed by the relative erosion resistance of the underlying rocks. From an elevation of 650 to 700 feet, the slope is steep (1 foot vertical to 7 feet horizontal) in response to the hard Ohio Shale. From 700 to 720 feet the escarpment is more terrace-like (1 foot vertical in 20 feet horizontal) under the influence of the soft Bedford Shale. From 720 to 850 feet the slope once again becomes steeper (1 foot vertical to 4 feet horizontal) where underlain by the resistant Berea Sandstone that forms the caprock for the escarpment.



Figure 34: Exposed bedrock located on the east branch of Old Woman Creek flowing through the Berea escarpment, (Hohman)

Soils of the escarpment are generally within the Mahoning-Bogart-Haskins-Jimtown association, particularly those of the Berk series (Redmond et al. 1971). Berk soils are acid, light-colored, well-drained, and underlain by weathered sandstone from which they have formed.

Berlin Heights Ravine. The ravine of OWC at Berlin Heights exhibits the maximum topographic relief in the watershed. From the floor of the creek to the top of the gorge, the vertical height of the walls reach a maximum of 90 feet and the width ranges from 300 feet to nearly 600 feet. The ravine begins at the foot of the Berea Escarpment, near the place where the Ohio Turnpike crosses the east branch of OWC, and extends south (upstream) for about one mile to Ohio Route 61. The creek bed drops 115 feet in a series of riffles as it passes through the ravine. Impressive exposures of Berea Sandstone can be seen in the upper walls of the ravine and Ohio Shale outcrops in the bed of the stream. A similar gorge occurs on the west branch of OWC where the stream cuts through the Berea Escarpment in the vicinity of Berlinville.

Till Plain. The southern half of the watershed consists of glacial till plain. This plain lies southeast of the highest Lake Maumee beach ridge, which generally coincides with the lakeward slope of the Berea Escarpment. The surface topography of the till plain slopes lakeward at an average of 26.4 feet/mile or 0.5% (Buchanan 1982). The till plain is a large expanse of glacially deposited ground moraine that extends



Figure 35: Rolling topography of the till plain region of watershed. (Hohman)

beyond the limits of the watershed to the Defiance end moraine in southern Huron County (nine miles south of Berlin Heights). The till plain is more rolling than the lake plain and represents an area over which the ice edge advanced and retreated rapidly without halting (Herdendorf 1963b). The plain is only moderately dissected by the tributaries of OWC and is otherwise only interrupted by scattered sandstone hills south of the Berea Escarpment. The highest sandstone hill in the area, at an elevation of 910 feet, lies at the southern boundary of the watershed (0.75 miles east of the community of

Collins, in Townsend Township, Huron County).

Soils of the till plain are generally within the Mahoning-Bogart-Haskins-Jimtown association, particularly soils of the Mahoning series, which form from moderately calcareous, clay-rich, glacial parent material (Redmond et al. 1971). The till typically consists of a tenacious clay matrix with imbedded rock fragments ranging in size from silt particles to boulders. Devonian black shale (Ohio Shale) chips constitute up to 90% of the recognizable rock types in the clay matrix. Carbonate and crystalline rocks occur as larger fragments in the cobble and boulder size ranges (Herdendorf 1963b).

Valley of Old Woman Creek. The network of tributary valleys in the OWC watershed forms a dendritic (tree-like) drainage pattern. The pattern of drainage within the watershed resulted from the sequence of glacial events that are discussed in the Glacial History of this inventory. After the initial withdrawal of glacial ice from the moraine complexes and till plain south of Lake Erie, consequent, dendritic streams began to form, flowing northward to the lake on the sloping till surface. The dendritic nature of early OWC resulted from the masking of any bedrock structure, such as joint or faults, by the overlying till, which was of rather uniform erodibility and moderate slope. No subsequent events have occurred to alter this drainage pattern.

The topographic character of the OWC valley is more fully discussed above in the Basin Topography section of this inventory.

Sub-basins. Although the Ohio EPA does not have a recognized system for breaking down 14-digit HUC watersheds like OWC into smaller sub-basins, separating the watershed into smaller basins is beneficial for targeting appropriate locations for implementation of different strategies. Old Woman Creek is split into five sub-basins that not only depict the three major landforms of the watershed (Lake Plain, Till Plain, and Berea Escarpment) but also consider spatial population density

and upper and lower reaches of the east and west branches. Names given to each basin were selected to establish a “sense of place” for the residents of the watershed, as such three sub-basin are named directly after communities found within (Berlin Heights, Shinrock, and Berlinville) that basin and two depict the ecogeographical characterization of the basin (Lake Plain and Till Plain).

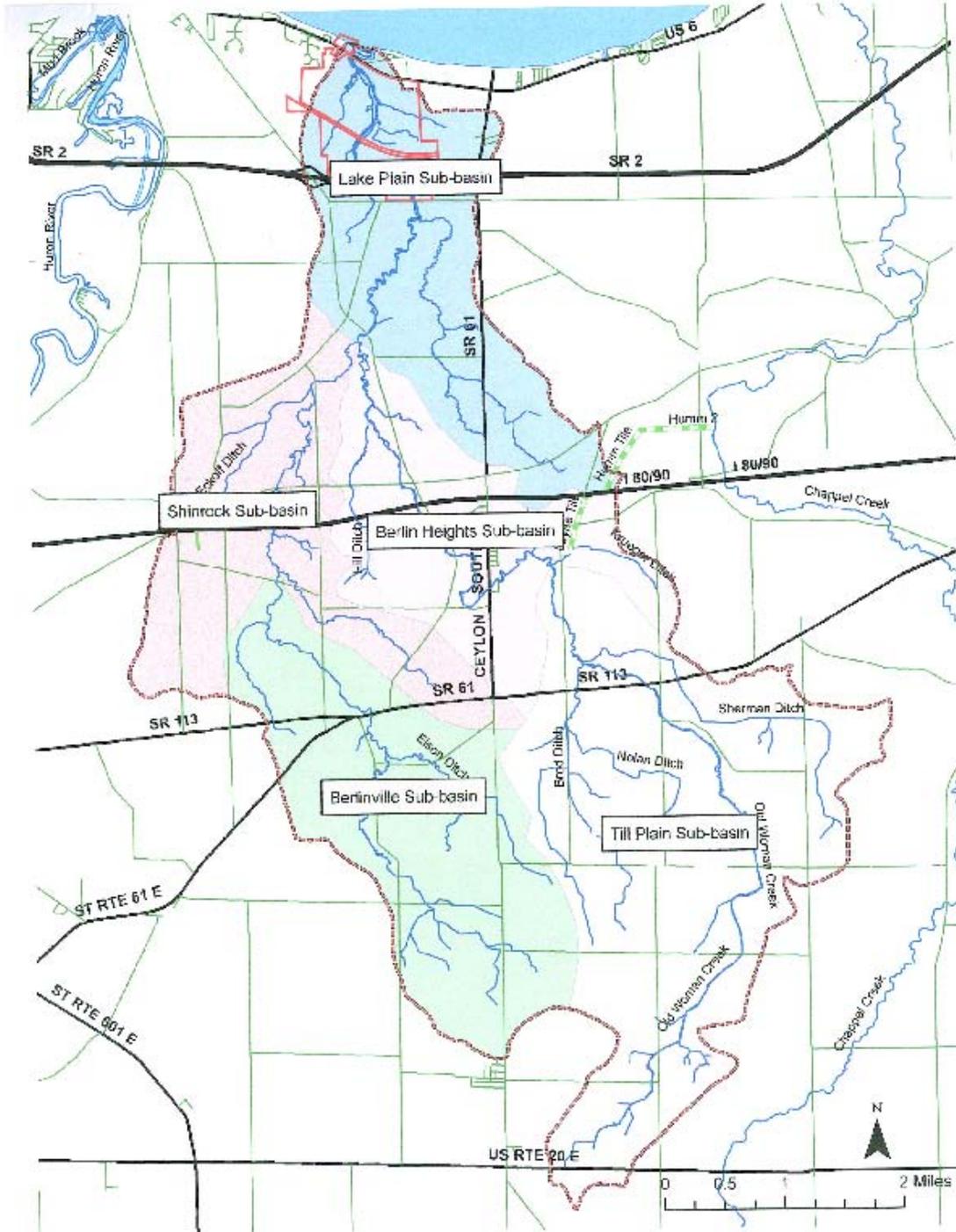


Figure 36: Sub-basins of OWC. (ODNR)

Table 3. Acreage of sub-basins for the OWC watershed.

| Sub-Basin | Acreage | Square Miles |
|------------------|----------------|---------------------|
| Lake Plain | 2,883 | 4.5 |
| Berlin Heights | 2,444 | 3.8 |
| Shinrock | 2,708 | 4.2 |
| Berlinville | 3,466 | 5.4 |
| Till Plain | 5,490 | 8.5 |

BEDROCK FORMATIONS

Geologic Age. All of the bedrock exposed in Ohio was deposited as sediment during the Paleozoic Era (570 to 245 million years ago); however, these sediments were deposited under differing environmental conditions during this long span of geologic time. The Paleozoic Era is subdivided into a number of geologic periods. Early Paleozoic environments (Ordovician, Silurian, and Middle Devonian Periods) were characterized by tropical to subtropical, shallow to moderately deep seas where bars and reefs abounded and lime muds were being deposited (a comparable modern-day environment is the Caribbean Sea). The limestone, dolomite, and calcareous shale bedrock of northwestern Ohio resulted from such deposits. Late Paleozoic environments (Late Devonian, Mississippian, Pennsylvanian, and Permian Periods) were characterized by streams, deltas, nearshore seas, and coals swamps (a comparable modern-day environment is the Mississippi delta in the Gulf of Mexico). The sandstones, siltstones, and shales of northeastern Ohio resulted from these deposits. The Old Woman Creek watershed is located just east of the junction of these depositional regimes, thus shale and sandstone are the dominant types of bedrock, namely from oldest to youngest—Ohio Shale, Bedford Shale, and Berea Sandstone.

Bedrock exposed in OWC watershed was deposited as sediment during a geologic time interval which spans the late Devonian and early Mississippian Periods, about 360 million years ago. There is still some debate and uncertainty as to the boundary of these periods within the bedrock formations of northern Ohio. The red and gray shales of the Bedford Shale Formation, immediately below the Berea Sandstone, appear to have been deposited shortly before for the Berea sands and most likely under similar conditions. Below the Bedford, the black and gray shales of the Ohio Shale Formation were deposited earlier and under quite different conditions and are clearly Late Devonian in age. South of the watershed, shales, siltstones, and sandstones of the Sunbury Shale and Cuyahoga Formation, that overlie the Berea Sandstone, are clearly Mississippian in age. Thus, the boundary lies somewhere within or at the top or bottom of the Berea-Bedford sequence of rocks.

Outcrop Pattern. No outcrops of bedrock are found along the Lake Erie shoreline in the vicinity of OWC. However, within 5 miles to the west and 10 miles to the east of the OWC estuary, black shale beds of the Ohio Shale Formation crop out in the bluffs of along the lakeshore at Huron and Vermilion, respectively. The Cleveland

Shale and Huron Shale Members of this formation underlay the thick glacial till and lacustrine (lake) deposits that underlay the estuary. The Ohio Shale is exposed in the bed of OWC a short distance north of Berlin Heights near the Mason Road bridge. Exposures of this shale continue upstream for several miles to the vicinity of Berlinville along the west branch and State Route 61 on the east branch of OWC.

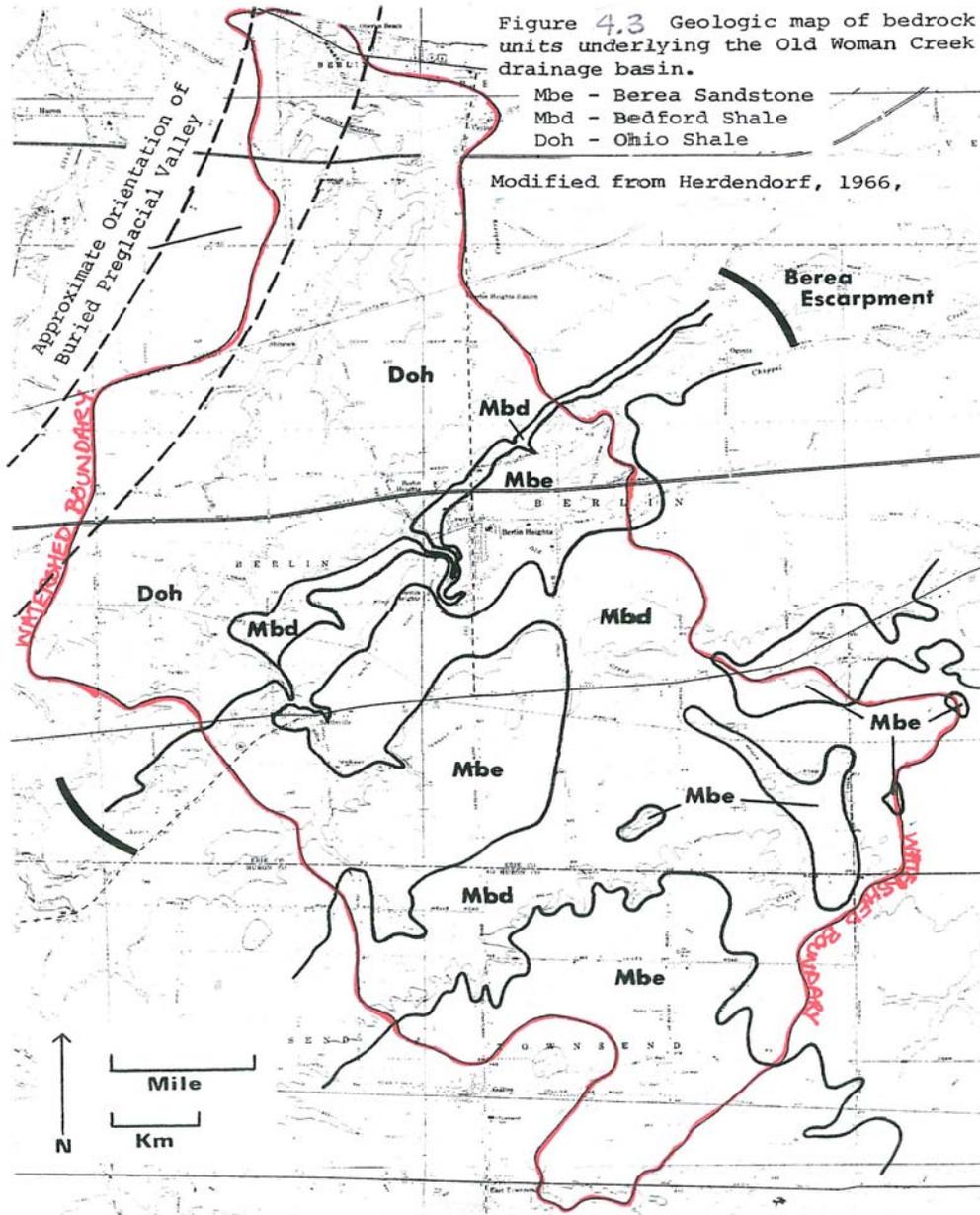


Figure 37: Geologic map of bedrock units underlying the OWC drainage basin: Berea Sandstone (Mbe), Bedford Shale (Mbd), and Ohio Shale (Doh). Modified from Herdenforf, 1966.

The red and gray shale beds of the Bedford Shale Formation overlie the Ohio Shale in the bluffs of the OWC farther upstream. However, exposures of the Bedford Shale are often indistinct because of the soft, clay-like nature of the shale, which results in slumping along the stream banks. Also, channel sandstones of the younger Berea Sandstone Formation often extend down through the Bedford Shale to rest directly on the Ohio Shale.

Channel sandstones range in thickness from a few feet to at least 260 feet at the Cleveland Quarries Company operation at South Amherst. Most channels appear to have a north-south trend, except for one near the Village of Berlin Heights, which runs more northeast-southwest and may represent a side distributary channel. Over 100 feet of sandstone is exposed in this channel at the abandoned Baillie Stone Company quarry northeast of the village. The water pool that has accumulated in the bottom of this quarry is noted for its population of nickel-sized, freshwater jellyfish (*Craspedacusta sowerbii*). Outside the quarry district, the Berea is a widespread sandstone, varying in thickness from 25 to 60 feet.

Bedrock Characteristics. *Sandstone* is sedimentary rock consisting of sand-sized grains cemented together, typically red, gray, yellow, or brown in color. The term *sandstone* when used without qualifiers, indicates a rock containing about 85–90% quartz grains. The cementing materials are commonly silica, iron oxide, or calcium carbonate. The sand from which sandstone is formed was once a loose aggregate of mineral and rock fragments that were larger than silt-sized particles, yet smaller than gravel-sized particles. In terms of dimensions, sand-sized grains of sediment are particles greater than $\frac{1}{16}$ mm (0.0025 inches) and less than 2 mm (0.08 inches) in diameter. Grains of this size are typically visible as individual particles to an unaided eye. Sedimentary rocks composed of smaller particles in massive layers are referred to as *siltstone*, while those with thin layers are known as *shale*.

GLACIAL HISTORY

Lake Erie owes its origin to physiographic changes induced by Late Cenozoic (Pleistocene) glaciers. During the long time interval between the deposition of Paleozoic sediments and the first glacial advance (250 million years), erosive forces cut a mature drainage system into the rocks that underlie present Lake Erie. As advancing or retreating ice sheets paused, ridges (or moraines) of glacial till were built up at the ice margins, damming the natural drainage. Large glacial lakes formed between the moraines and the ice front. Lake Erie and Old Woman Creek estuary are remnants of a series of glacial lakes that, at its earliest and highest stage, extended as far southwest as present day Fort Wayne, Indiana and drained in that direction via the Mississippi River system. As the ice retreated from this position other outlets were uncovered and new lake stages were formed at successively lower elevations. In a few instances readvances of the ice blocked outlets and temporarily caused higher lake levels. Sandy beach ridges and wave-cut cliffs, 1 to 4 miles inland of the estuary, mark the position of these former lakes.

When the last glacier retreated from the Niagara River area a new and final outlet was available. Initially this outlet was at a considerably lower elevation than at present because of crustal depression under the weight of the glacial ice. Thus, the last glacial lake quickly drained through this new opening and much of the present bed of Lake Erie was dry for an extended period. Eventually the Niagara outlet began to rebound from its depressed position and modern Lake Erie was formed as the lake waters flooded the shore and tributary mouths, creating freshwater estuaries.

The sequence of events that have taken place in the evolution of Lake Erie began about 14,500 years before the present (YBP) when the last Pleistocene glacier, known as the Wisconsinan ice sheet, temporarily halted in its retreat. Although the ice front was in a stationary position over northwest Ohio, northeast Indiana, and southeast Michigan (rate of ablation and rate of advance in equilibrium), forward transport of drift continued under the ice, creating the Fort Wayne end moraine at the ice margin. The position of this moraine is approximately along the drainage divide between the St. Lawrence and Mississippi River systems, about 20 miles southwest of the Old Woman Creek drainage basin. As the ice eventually retreated from the Fort Wayne moraine, water was ponded between the ice front and the moraine, thus starting a 2,000-year sequence of glacial lakes in the Erie basin.

Table 4. Glacial and post glacial lakes of OWC watershed.

| LAKE STAGE (YBP) | ELEVATION (FT) | AGE |
|----------------------------|----------------|---------|
| Lake Maumee | 800 | 14,400- |
| 13,800 | | |
| Lake Arkona | 700 | 13,800- |
| 13,600 | | |
| Lake Ypsilanti (low stage) | 260 | 13,600- |
| 13,000 | | |
| Lake Whittlesey | 740 | 13,000- |
| 12,800 | | |
| Lake Warren | 680 | 12,800- |
| 12,700 | | |
| Lake Wayne | 660 | 12,700- |
| 12,600 | | |
| Lake Grassmere | 640 | 12,600- |
| 12,500 | | |
| Lake Lundy | 620 | 12,500- |
| 12,400 | | |
| Early Lake Erie | 490 | 12,400- |
| 8,000 | | |
| Middle Lake Erie | 525 | 8,000- |
| 3,000 | | |
| Modern Lake Erie | 570 | 3,000- |
| present | | |

SURFACE DEPOSITS

Glacial Deposits. Approximately one million years ago, great ice sheets began to move southward and westward out of Canada and into the Erie basin. Several glacial lobes, some as much as a mile thick, moved up pre-glacial river valleys. One of these, the Eriean River valley, ran in a general northeast direction up the basin now occupied by modern Lake Erie (Spencer 1991). The scouring action of the glacier enlarged the valley, forming a broader and deeper the Erie basin (Bolsenga and Herdendorf 1993). During and after the retreat of the last glacier, up to 115 feet of glacial till and 250 feet of sediment have been deposited in the glaciated valley (Wall 1968) to give modern Lake Erie a much smoother and flatter bottom than it had when water first filled the basin.

As the Pleistocene glaciers followed the ancient streams into Ohio, the valleys were scoured deeper and the meanders were smoothed. The resistant bedrock that underlies Erie and Huron counties was not deeply cut by glacial ice, but profound erosion features are evident in the area, such as the spectacular glacial grooves in the Columbus Limestone on Kelleys Island and the massive overturned slabs of Berea Sandstone in the Chappel Creek valley, Florence Township. As the ice sheets moved over the land a sheet of rock debris, or ground moraine, was deposited. When the glaciers paused in their advance or retreat, ridges known as end moraines were built up of rock debris at the ice margins. The debris, referred to as glacial till, is composed of a heterogeneous mixture of rock fragments ranging in size from clay to boulders. In places, end moraines were deposited in such a way as to dam the natural drainage and thereby form large lakes in the scoured depressions.

Nearly all unconsolidated material overlying the bedrock in the vicinity of Berlin Heights and the Old Woman Creek drainage basin is glacial in origin, deposited either directly by the Wisconsin ice sheet or in glacial lakes that were predecessors of Lake Erie. The contact line of ground moraine and lacustrine sediments was adapted from maps prepared by Herdendorf (1966) and Redman et al. (1971). Gently rolling ground moraine, late Wisconsin in age (Campbell, 1955), covers the southern portion of the Old Woman Creek drainage basin to an average depth of 25 feet. Notable exceptions are hills of Berea Sandstone, which have little or no till cover, and, at the estuary mouth where a buried valley is filled with 147 feet of glacial drift and lake sediments (Buchanan 1982). South of the present shoreline, beach deposits of six glacial lake stages have been recognized: Lake Maumee, Lake Whittlesey, Lake Arkona, Lake Warren, Lake Wayne, and Lake Lundy, from highest to lowest. Glaciolacustrine deposits formed in these lakes are thin and discontinuous except in the vicinity of the beach ridges, and are best exposed in the present lake bluffs. Widely scattered lagoonal deposits are present in the beach ridge area and in places contain minor deposits of peat and bog ores.

Huron River Embayment. Immediately west of the Berea Escarpment in southeastern Erie County, a sharp indentation is present in all of the abandoned shorelines of the glacial lake stages. The Huron River entered the lakes through this bay and was the primary factor in controlling sedimentation in the area. Carney

(1911) applied the name “Huron River embayment” to this area which encompassed the northern part of Old Woman Creek watershed and extended westward to the base of Cedar Point and southward to Norwalk. Campbell (1955) referred to the body of water within this area at the various lake stages as “Huron Bay.”

The bedrock of the embayment comprises an area of lower elevation, carved out of shale, when compared to the higher elevations of the more resistant sandstone of the escarpment to the east and the limestone terrain to the west. While the bay existed, the limestone terrain formed either a northeasterly trending peninsula or a string of islands. Likewise, the eastern edge of the embayment was controlled by the position of the Berea Escarpment and exhibits wave-cut features.

Glaciolacustrine Deposits. Sediments deposited in the glacial lakes comprise the Lake Erie bluffs from Huro east to Vermilion. These glaciolacustrine deposits consist largely of interlaminated clay and silt; the clay laminations are dark brown and the silt layers are light brown on weathered surfaces. The mineralogy of the clay is illite with minor amounts of chlorite (Carter and Guy 1980). Near the contact with the underlying till, the clay and silt laminations are poorly defined and there is typically a zone of deformed clay and silt.

The glaciolacustrine deposits that comprise the lake bluff at Ceylon Junction, about 1 mile east of Old Woman Creek estuary, were studied by Goodman (1956) and found to consist of sand (1.6%), silt (68.2 %), and clay (30.2%). When fresh these lake deposits are typically bluish gray, but exposed surfaces have brownish-gray and yellow-brown mottles caused by oxidation and staining. Exposures in the Lake Erie bluffs in the vicinity of the estuary indicate that the ancient lake deposits constitute only the upper 20 feet of the sediment. These beds show distinct interlaminations of silt and clay. Contorted stratification occurs in the lower 10 feet of the lacustrine beds at Oberlin Beach. This disturbed stratification has been attributed to penecontemporaneous slumping or distortion caused by ice flows associated with a minor ice advance or reworking by wave action (Campbell 1955, Herdendorf 1963b).

Varves. The bluffs of Old Woman Creek estuary, particularly those on the east side of the estuary immediately south of the U.S. Route 6 bridge, and the Lake Erie bluffs fronting Oberlin Beach to the east of the estuary mouth exhibit glaciolacustrine varves. These sedimentary beds are composed of a sequence of laminae deposited in a glacial lake in a year's time. Each varve consists of a thin pair of graded glaciolacustrine layers seasonally deposited by meltwater streams in a glacial lake which existed in front of the glacier. The glacial varves at Old Woman Creek include a lower “summer” layer, composed of relatively coarse-grained, light-colored silt and very fine sand produced by rapid melting of ice in the warm months, which grades upward into a thinner “winter” layer, consisting of very fine-grained clayey sediment, often organic and dark-colored, slowly deposited from suspension in quiet water while the streams were ice-bound. A sedimentary feature that is characterized by the repetition of a pair of unlike laminae showing a gradation in grain size from coarse

below to fine above is said to possess diatactic structure (Bates and Jackson 1980). Campbell (1955) measured interlaminated lacustrine deposits west of the Huron River that averaged 8.0 mm (0.31 inches) per couplet, but she was uncertain if they represented true glacial varves because diatactic structure could not be demonstrated. However, the interlaminated silts and clays at the estuary appear to have been deposited in the higher glacial lakes stages from Lake Maumee to Lake Lundy.

Counting the number of couplets can provide a measure of the time sequence represented by a particular deposit. For example, varve couplets measured by Herdendorf et al. (2004, 2006) near the mouth of Old Woman Creek estuary average 10.3 mm (0.41 inches) in thickness. The maximum height of the varved deposits ranges from 20 feet on the lakeshore to 12 feet in the estuary. Hence, the bluffs near the mouth of the estuary represent a depositional period of nearly 600 years or about 36% of total time that higher glacial lakes covered the estuary site.

Post Glacial and Modern Sediments. The oldest alluvial sediments were deposited within the channel of Old Woman Creek and on the narrow floodplain across which the channel migrated about 8,000 YBP. These sediments exist 6 m below the current estuary floor and consist of coarse to fine sands and silts deposited in the more swiftly flowing channel of the creek when the level of Lake Erie was much lower and the stream possessed a higher gradient. As the lake rose, the stream gradient of Old Woman Creek was reduced and the site of the estuary experienced increasing amounts of sediment deposition involving finer and finer sediments. As deposition progressed and the floor of the estuary rose in elevation, the size of the area over which the creek channel migrated increased, eventually to encompass and laterally enlarge the deep valley cut in the underlying lacustrine sediments and till by the early, erosive channel of the creek. Currently, only silts and clays are transported into and deposited in the estuary of Old Woman Creek (Buchanan 1982).

Within the last 100 years, the combined effects of rising lake levels and sediment deposition may have decreased the water depth in the estuary to such a degree that shallow-water aquatic vegetation has begun to colonize its floor (Buchanan 1982). The first indication of this colonization are zones of dark, organic-rich sediments with plant debris in the upper 3 feet of cores recovered from the estuary. Using recent lake-level records and aerial photographs, Buchanan estimates that shallow water depths, 6 to 12 inches, are necessary for such vegetation to flourish and that conditions such as these were present in the estuary between the 1920s and 1960s. A more recent core (Reeder 1989) reveals deeper, organic-rich layers which may indicate even earlier low-water/high productivity periods in the estuary. Using Buchanan's radiocarbon data, the sediment depositional rate in the estuary over the last 8,000 years has averaged 0.70 mm (0.03 inches) per year. Most likely this rate has been greatly accelerated in the last 100 years due to agricultural development within the drainage basin. Current depositional rates in the estuary are estimated by Buchanan to be 10 mm (0.4 inches) per year.

Matisoff et al. (1998) demonstrated that the type of soil tillage has an influence on the erosion rate in Old Woman Creek watershed and the ultimate delivery of sediment to the estuary. They selected several drainage sub-basins for study where agricultural management included either tilled or no-till practices. By using an a radioactive isotope of beryllium as a tracer, they were able to track soil erosion losses for each sub-basin for a single rainstorm event in 1996. The results of the study showed the advantages of no-till practice in controlling soils loss:

| <u>Practice</u> | <u>Mean Sub-basin Size</u> | <u>Erosion Rate</u> |
|-----------------|----------------------------|---------------------|
| Tilled | 536 acres | 9.8 lbs/acre |
| No-till | 536 acres | 1.1 lbs/acre |

Because most of Lake Erie's undisturbed estuary inlets are barred across a significant portion of the year, it has been postulated that the presence of such barriers control, to a large part, sediment infilling within the estuary (Herdendorf 2004). Buchanan (1982) noted that recent depositional rates in Old Woman Creek estuary may range as high as 1 cm/yr (0.4 inches/year) in response to increased agricultural activity upstream and the damming effect of the barrier bar at the estuary mouth. He also concluded that colonization of the estuary floor by aquatic plants has only become possible in that period of time represented by the upper meter of sediment (100 years assuming a sedimentation rate of 1 cm/yr), because water depth appears to be the dominant control for plant abundance.

More recent findings do not show a quite different picture. Water levels in Lake Erie have varied considerably in the past 12,000 years, falling from 810 feet to 480 feet then up 570 feet above sea level due to isostatic adjustment following deglaciation. Approximately 4,000 to 5,000 YBP the lake stabilized near its present level and has fluctuated only a few meters up and down since. Once the lake stabilized, barrier bars were deposited across the drowned mouths of most of the tributaries, forming what is now referred to as freshwater estuaries. Sediment cores (Reeder 1989) indicates that peat layers composed of aquatic plant material extend for several meters below the estuary floor and yield radiocarbon dates of 4,000 to 5,000 YBP. Apparently colonization by aquatic plants is not a new feature of the estuary, but there must have been some mechanism operating through time to control water level at depths optimal for plant growth.

Beach Deposits. Old Woman Creek does not enter Lake Erie in the usual way—it must first pass through the barrier beach. At times the barrier is opened by a channel, which leads to the lake, but often it is closed by sand bars. When the estuary mouth is completely sealed off by the barrier beach, the creek waters must percolate through the sand to find their way to the lake. Wind storms over the lake and rainstorms over the watershed can produce the forces necessary to breach the barrier and allow Old Woman Creek to flow freely to the lake. Once these violent events have subsided however, the shifting sands of the coast can quickly close the channel, isolating the estuary from the open lake. The barrier is critical to the

protection and maintenance of coastal wetlands. By separating estuary from the lake, fragile aquatic plants are protected from wave attack. The beach allows the waves to break and roll up a gentle slope, dissipating energy and reducing the waters ability to eroded the shoreline and undermine vegetation.

At the mouth of Old Woman Creek, the barrier beach is composed of medium- to coarse-grained sand. Quartz dominates these grains, but patches of reddish-purple garnet and black magnetite are common. These three materials are typically arranged in density layer, with the heavier magnetite lowest on the beach, followed by garnet, then and quartz. Waves carrying the grains of sand onto the beach are effective in sorting these minerals by their specific gravity (Herdendorf 1963b). The beach sand has a maximum thickness of 23 feet and overlies glacial till that is exposed at the shoreline east of the barrier beach.

SOILS

SOIL SCIENCE

Soil science can be subdivided into two disciplines: (1) pedology—the study of soil morphology, properties, genesis, and classification and (2) agronomy—soils management and crop-producing characteristics. Both aspects are important in understanding the natural setting and land use patterns in OWC watershed as well as the impact of soils on the ecology of the estuary. Soils surveys of the watershed have been included in surveys of Erie County (Redmond et al. 1971, Martin and Prebonick 1994) and Huron County (Ernst and Martin 1994). In addition, a survey of adjacent Lorain County (Ernst et al. 1976) provides further insight to soils characteristics of the region. (Herdendorf et al. (2004, 2006) used the soils surveys of OWC watershed, plotted on aerial photographs, to determine the acreage of each soil type. A total of 67 different kinds of soils have been mapped in the 17,376 acres that comprise the OWC watershed. Of these, 10 soil types account for nearly 60% of the watershed (Table 4.3)

Table 5. Most common soil types in OWC watershed.

| SOIL NAME | MAP SYMBOL | ACRES | WATERSHED (%) |
|-------------------------|------------|------------|---------------|
| Bennington silt loam | BgA | 3,227 | 18.6 |
| Cardington silt loam | CaB | 1,018 | 5.9 |
| Haskins loam | HkA | 862 | 5.0 |
| Condit silt loam | Co | 810 | 4.7 |
| Bennington silt loam | BgB | 808 | 4.7 |
| Mermill silty clay loam | Me | 778 | 4.5 |
| Elnora loamy fine sand | EnA | 770 | 4.4 |
| Bixter loamy fine sand | BkA | 729 | 4.2 |
| Kibbie fine sandy loam | KbA | 655 | 3.8 |
| Holly silt loam | Ho | <u>650</u> | <u>3.7</u> |
| | TOTAL | 10,307 | 59.5 |

The soils in the watershed occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each soil type is associated with a particular landscape. For example, Shinrock soils (typical of the side slopes of OWC) formed under forests of red oak, white oak, black oak, and other hardwoods. In contrast, Miner soils formed in poorly drained depressions under swamp forests, such as near the headwaters of OWC southwest of the Village of Berlin Heights. Sisson soils formed on low, dry knolls at the southern end of the estuary, presumably under prairie vegetation. The thick, dark-colored surface layer indicates that the native forest was thin enough to permit the growth of a dense stand of prairie grasses.

Parent Material. The underlying material is a dominant factor in the formation of most of the watershed soils, largely determining the chemical nature and mineral composition of the soil. Parent materials in the watershed are sedimentary bedrock, glacial till, glacial outwash, ancient lake deposits, recent stream alluvium, and organic material (Table 4.4). The various types of parent material in the watershed are associated with specific soils. The watershed was covered by glaciers during the Pleistocene epoch, thus, glacial till is the major parent material of the soils. Bennington, Cardington, and Condit are examples of soils that formed in glacial till. Beach ridges and deltas formed along the edges of a series of glacial lakes. Elnora, Oshtemo, and Spinks are examples of soils that formed in these deposits. Outwash of silt, sand, and gravel was deposited by meltwater along glacial streams. Chili and Jimtown soils formed in glacial outwash. Lacustrine material consisting of loamy to clayey sediment was deposited in glacial lake in the northern part of the watershed. Kibbie, Shinrock, and Tuscola soils formed in lake and outwash deposits.

Table 6. Parent materials of OWC watershed soils.

| PARENT MATERIAL | SOIL TYPES (No.) |
|----------------------------|------------------|
| Bedrock | 3 |
| Glacial Till | 14 |
| Glacial Outwash | 12 |
| Ancient Beach Ridges | 8 |
| Lacustrine (Lake) Deposits | 23 |
| Delta Deposits | 3 |
| Floodplain Alluvium | 3 |

Soil Limitations. The varying properties and limitations of the soils in OWC watershed influence the types of land use activity found in the watershed. 38 watershed soil types are considered prime farmland, accounting for 82% of the land surface. Limitations of the various soils in the watershed, including slope, drainage, water table elevation, depth to bedrock, and hazard/erosion probability. Flooding is the most common hazard, but only four soils (Holly, Nolin, Orrville, and Tioga) pose serious problems. These soils occupy about 4% of the watershed's surface soils. Most soils in the watershed have low to moderate erosion factors, but sediment delivered to the estuary and Lake Erie can have deleterious effects.

SOIL EROSION AND SEDIMENT YIELD

Soil erosion and resultant sediment yields in the watershed impact the water quality and infilling of OWC estuary. Soil erosion is the removal rate of soil particles from a specified area per unit time, either measured in soil mass or soil thickness, whereas, sediment yield refers to the rate at which sediment passes a particular point in a drainage basin per unit time. While soil erosion values can be used to document the annual soil loss at a specific location, sediment yield values provide a measure of the flow of sediment through a drainage basin. Sediment yield depends on: (1) input from soil erosion, mass wasting, and, atmospheric fallout, (2) temporary storage in the form of deposition in stream valleys and upland gullies or rills, and (3) output comprised of stream sediment load and wind-carried sediment.

Stream sediment loads are typically divided into three components: (1) bedload (particles that slide, roll, or swirl along the stream bed), (2) suspended load (particles that are carried in the water column, generally by turbulence), and (3) dissolved load (chemicals in solution or adsorbed to colloids).

Using a GIS based model, Evans and Seamon (1997) found that soil erosion within the OWC watershed varied from 0.6 to 39 tons/acre/year depending on soil type, topography, rainfall, and land use practices. Using a basin-wide average of 3 tons/acre/year, this equates to a total soil loss of 50,484 tons/year for the entire OWC watershed. These values compare reasonably well with corrected calculations made by Buchanan (1982) using the Universal Soil Loss Equation (USLE)—average soil loss of 2.3 metric tons/acre/year. The higher value obtained by Evans and Seamon (1997) are most likely a consequence of their greater sampling density and the use of the Revised Universal Soil Loss Equation (RUSLE). The southeastern portion of OWC watershed appears to be the most significant in terms of soil erosion, sediment yield, and resultant loadings. This region is characterized by Bennington-Cardington-Condit association soils, which have the highest erodibility in the watershed. This region also lies at the transition from till plain to escarpment where the slopes are greatest.

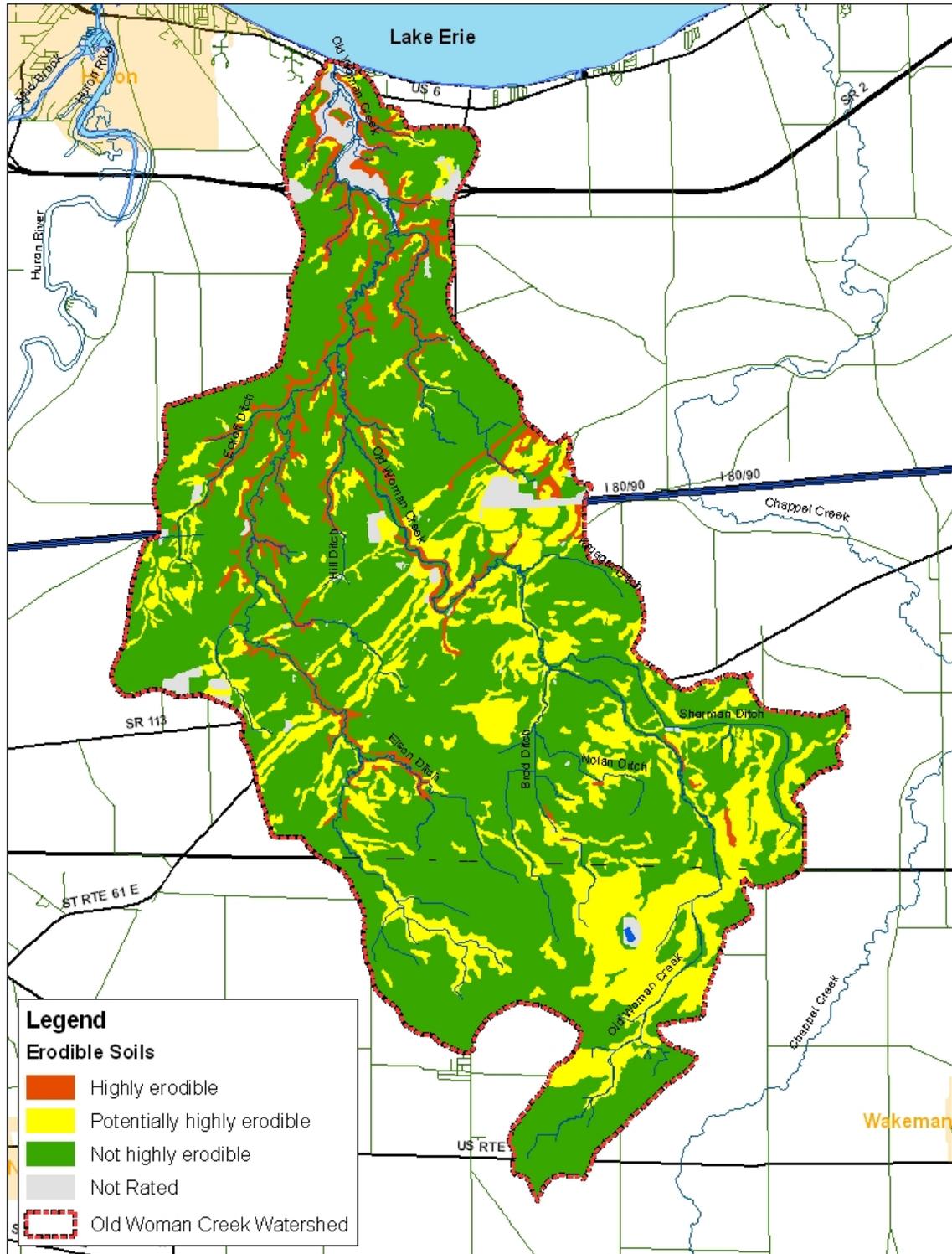


Figure 38: Erodible soils found in the vicinity of Old Woman Creek, watershed boundary is marked in red. (ODNR – Steve Barry)

Extrapolation of soil loss data to sediment yields requires the calculation of delivery ratios, or inversely, interbasin storage ratios, for the watershed. Delivery ratios refer to the percentage of eroded sediment that is transported to a specified point in the watershed, essentially the amount of soil erosion less redeposited sediment in the form of storage. Evans and Seamon (1997) calculated sediment delivery ratios for the watershed above the estuary (84% of basin). They found that the annual suspended sediment load (approximately 3,400 tons/year) is 30-35% of the total average annual stream sediment load (approximately 10,500 tons/year). The calculated delivery ratios ranged from 21–25%, indicating that interbasin storage is between 75-79% of the soil eroded within the drainage basin. Thus, on the average it takes four to five years for soil eroded in the watershed to make its way to the estuary. Considering that the estuary has a volume of approximately 12 million cubic feet (Herdendorf and Hume 1991) and using a specific gravity of about 2.0 for compacted sediment (Lyon and Buckman 1943), the annual sediment load to the estuary of 10,500 tons (equivalent to 185,400 cubic feet) would completely fill the estuary in some 65 years if sediment was not passed through to Lake Erie. The sediment balance in the estuary appears to be at a near steady-state condition as a good deal of the annual sediment load is eventually resuspended and carried to the lake.

Table 7. Erodeable Land in OWC watershed (HEL- Highly Erodeable Land, PHEL- Potentially Highly Erodeable Land)

| Sub-basin | Total basin acres | Total HEL acres | Percent HEL | Total PHEL acres | Percent PHEL | Total erodeable acres |
|----------------|-------------------|-----------------|-------------|------------------|--------------|-----------------------|
| Lake Plain | 2,883 | 387 | 13% | 267 | 9% | 654 |
| Shinrock | 2,708 | 174 | 6% | 331 | 12% | 505 |
| Berlin Heights | 2,444 | 160 | 6% | 609 | 25% | 769 |
| Berlinville | 3,466 | 88 | 3% | 444 | 13% | 532 |
| Till Plain | 5,489 | 23 | 0.4% | 1084 | 20% | 1107 |

HYDRIC SOILS

Hydric soil are defined as soils formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper soil profile. The concept of hydric soils, as described by NRCS, includes soils developed under sufficiently wet conditions to support the growth and regeneration of hydrophytic vegetation (wetland plants). Soils that are sufficiently wet because of artificial measures are included in the concept of hydric soils. Also, soils in which the hydrology has been artificially modified are hydric if the soil, in an unaltered state, was hydric. Some series, designated as hydric, have phases that are not hydric depending on water table, flooding, and ponding characteristics. In the OWC watershed approximately 20% of the soil content is considered to be hydric. As shown in Table 7, much of the hydric areas are found north of the Berea escarpment in the Erie/Ontario Lake Plain ecoregion and following the stream channel south of the escarpment in the Eastern Cornbelt Plain ecoregion.

Table 8. Hydric soils of the OWC Watershed by sub-basin.

| Sub-basin | Total acres | Total Hydric areas (acres) | Percent hydric |
|----------------|-------------|----------------------------|----------------|
| Lake Plain | 2,883 | 801 | 27.8% |
| Shinrock | 2,708 | 601 | 22.2% |
| Berlin Heights | 2,444 | 638 | 26.1% |
| Berlinville | 3,466 | 757 | 16.0% |
| Till Plain | 5,489 | 557 | 14.0% |

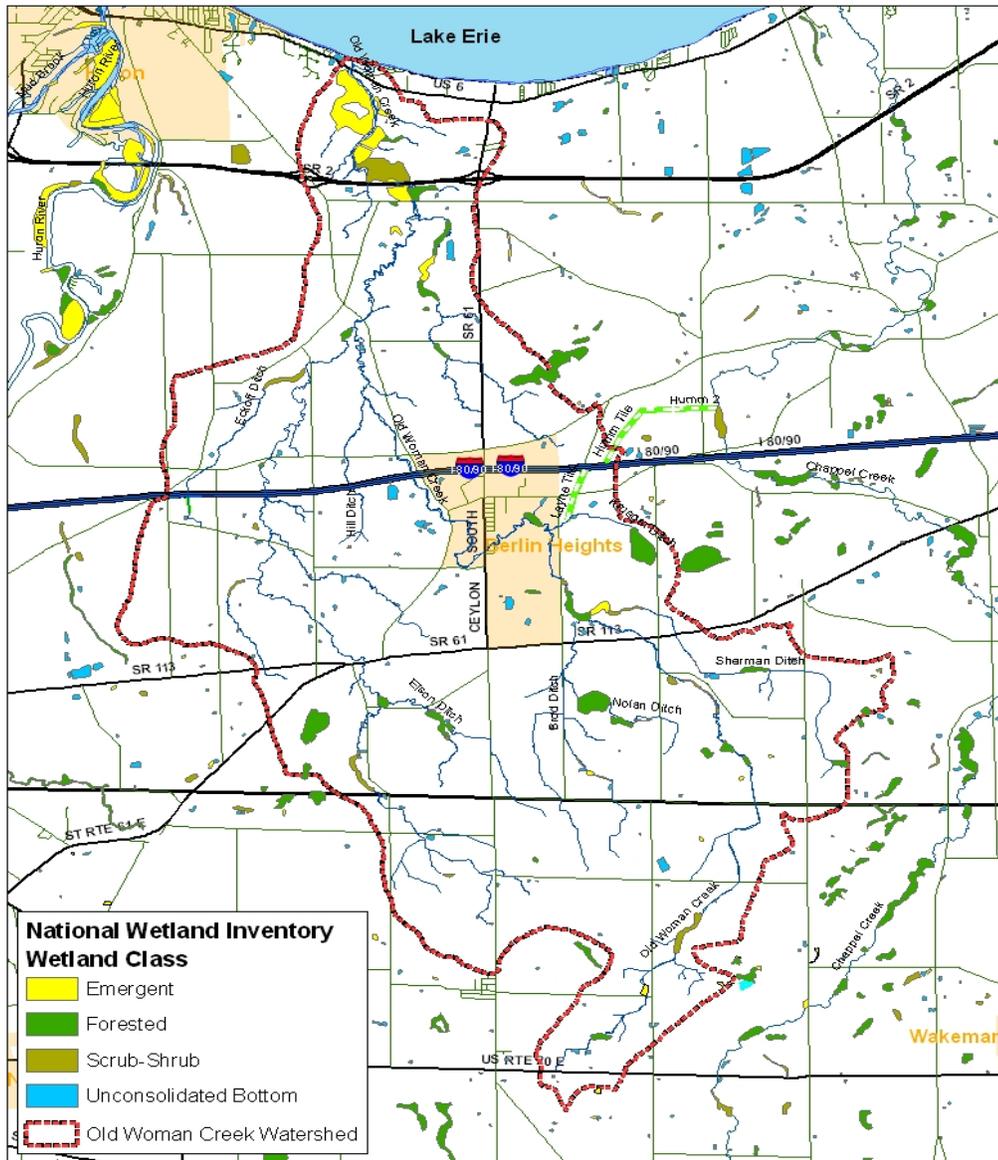


Figure 39: National Wetland Inventory of OWC watershed, illustrating wetland class categories (ODNR – Steve Barry).

CLIMATE

The climate of north-central Ohio is classified as “temperate, humid continental, long summer,” which signifying a middle latitude location (35° to 45°) in the interior of a large land mass well removed from oceanic influences with ample rainfall, warm to hot summers, and cold winters. These climatic characteristics are expressed in four distinct seasons, large seasonal temperature ranges, frequent precipitation, and sudden changeability with the rapid passage of different weather systems through the area. While the prevailing winds are from the southwest, one or two weather disturbances affect the OWC watershed each week, bringing changes in wind direction, overcast skies, and often precipitation. The settled weather associated with high-pressure systems is thus interrupted every few days by disturbances such as fronts or low-pressure areas which can bring warm subtropical air from the south or cold Arctic air from the north (Schmidlin 1996).



Figure 40: Old Woman Creek estuary in winter. (Elmer)

Thus, the climate of the watershed is marked by large fluctuations in temperature and precipitation (Table 9). Because of the proximity to the lake, northerly winds tend to lower daily temperatures in the summer and raise them in the winter. The growing season in the watershed averages 198 days (frostless days). Summers are moderately warm and humid with about 16 days where the temperature exceeds 90°F. Winters are generally cold and cloudy, however, the tempering effect of the lake

limits subzero temperatures on the average to only 3 out of 5 years. As is typical for continental climates, precipitation is highly variable on a yearly basis, but in the watershed it is generally abundant and evenly distributed with autumn being the driest season. Average annual precipitation is approximately 34.2 inches, highest in June (mean 4.1 inches; greatest 12.5 inches) and lowest in October (mean 2.0 inches). Winds average 6.2 miles/hour in the summer and 8.6 miles/hour in the winter. Although the prevailing winds are southwesterly, the southern coast of Lake Erie has a history of severe storms from the northeast and northwest that have caused extensive damage to and recession of the shoreline (Carter and Guy 1980).

Table 9. Seasonal Climatological Characteristics of OWC Watershed.

| | | | | |
|--------------------------------|---------|---------|---------|--|
| Average Weather Conditions | | | | |
| Sunny Days: | | | | |
| Jan-Mar | Apr-Jun | Jul-Sep | Oct-Dec | |
| 32 | 49 | 59 | 36 | |
| Rainy Days: | | | | |
| Jan-Mar | Apr-Jun | Jul-Sep | Oct-Dec | |
| 16 | 20 | 15 | 14 | |
| Thunderstorm Days: | | | | |
| Jan-Mar | Apr-Jun | Jul-Sep | Oct-Dec | |
| 1 | 14 | 15 | 1 | |
| Snowy Days (> 1 inch): | | | | |
| Jan-Mar | Apr-Jun | Jul-Sep | Oct-Dec | |
| 7 | 0 | 0 | 3 | |
| Hot Days (> 90°F): | | | | |
| Jan-Mar | Apr-Jun | Jul-Sep | Oct-Dec | |
| 0 | 11 | 8 | 0 | |
| Cold Days (< 32°F): | | | | |
| Jan-Mar | Apr-Jun | Jul-Sep | Oct-Dec | |
| 70 | 10 | 0 | 42 | |
| Average Air Temperature | | | | |
| Minimum Daily (°F): | | | | |
| Jan-Mar | Apr-Jun | Jul-Sep | Oct-Dec | |
| 24° | 51° | 62° | 36° | |
| Maximum Daily (°F): | | | | |
| Jan-Mar | Apr-Jun | Jul-Sep | Oct-Dec | |
| 38° | 69° | 80° | 51° | |
| Average Lake Temperature (°F): | | | | |
| Jan-Mar | Apr-Jun | Jul-Sep | Oct-Dec | |
| 35° | 55° | 72° | 46° | |
| Total Precipitation | | | | |
| Rainfall Equivalent (inches): | | | | |
| Jan-Mar | Apr-Jun | Jul-Sep | Oct-Dec | |
| 7.4 | 10.7 | 9.6 | 6.3 | |
| Snowfall (inches): | | | | |
| Jan-Mar | Apr-Jun | Jul-Sep | Oct-Dec | |
| 19.1 | 1.1 | 0.0 | 8.6 | |

Lake Erie has a modifying effect on the weather in the OWC watershed. Winds off the lake tend to lower the air temperatures on summer days and raise them on winter days. The daily variation in air temperature becomes greater with increasing distance from the lake and the average annual precipitation increases slightly. Compared with the lakeshore, the southernmost part of the watershed has an average daily maximum 1.5°F higher, an average daily minimum 4.2°F lower, and average annual precipitation that is about 1.1 inches greater (Miller 1971). The frost period (interval between the first freezing date in the fall and the last freezing date in the spring) increases as the distance from the lake increases. This yields a longer growing season near the lake shore than in the southern part of the watershed:

Huron (on Lake Erie)
 Berlin Heights (4 miles south of Lake Erie)
 Norwalk (11 miles south of Lake Erie)

Growing Season
 198 days
 168 days
 154 days



Figure 41: Apple orchard located in the Till plain sub-basin of Old Woman Creek. (Hohman)

Because water has a higher specific heat (capacity to absorb thermal energy in relation to temperature change) than soil, Lake Erie changes temperature more slowly than land surfaces of the watershed, delaying the change of seasons along the shore. Lake Erie absorbs a great amount of heat in the spring and summer with a relatively small change in temperature and slowly releases that heat in the fall and winter. The heat capacity of water

not only permits the lake and estuary to act as a buffer against wide fluctuations in the coastal

environment, it narrows the range of temperatures to which an aquatic organism is subjected as compared to those organisms living on land. Lake temperatures rarely exceed 80°F, whereas air temperatures as high as 108°F have been recorded in the vicinity of the watershed.

Southwesterly winds prevail over the watershed in all months of the years, a feature common to temperate regions of the northern hemisphere. In fall and winter, northwesterly winds can also occur frequently, reaching velocities of 40 to 50 miles/hour during severe storms (Herdendorf 1987). In spring, winds from the northeast are common, with storms producing velocities of 30 to 40 miles/hour. Thunderstorms typically occur in the watershed on 30 to 40 days each year. Tornadoes within an 50-mile radius of the watershed have a mean frequency of 3.9 per year. The most devastating tornado to hit the area was in 1924, when extensive damage and loss of life occurred in



Figure 42: Peak flow in Old Woman Creek shortly after a storm event. (Van Zoest)

Sandusky and Lorain, Ohio, communities within a 25-mile radius of the watershed. Storm events have a major impact on the water quality and quantity in OWC estuary as well as the biota dwelling there. When heavy rainstorms occur, turbid and

chemically-laden waters flood the estuary from the watershed, frequently breaching the barrier beach and opening a connection with Lake Erie. Under these conditions, the estuary is unable to assimilate watershed contaminants. When the barrier is open, lake biota can form a significant part of the flora and fauna of the estuary. However during periods with no severe storms, the barrier beach remains closed giving the estuary time to transform contaminants or settle them to the bottom. Estuary waters are further cleansed as they slowly percolate through the sands of the barrier beach. When the barrier is closed the biota in the estuary is distinctly different than that of Lake Erie.

Lee et al. (1995) studied the impacts of climate change on water levels in western Lake Erie resulting from a doubling of atmospheric carbon dioxide. Under this climate scenario, Detroit River flow would decrease by 36%, which would result in a 5 foot drop in the long-term average annual water level for Lake Erie. A decline in

water level of this magnitude would result in very significant decreases in water volume and surface area. Water volume for Lake Erie would fall 20%, and surface area decrease would result in the losses of wetlands, freshwater estuaries, and embayments. Estuaries, such as Old Woman Creek estuary, would only be inundated during lake storm events or when levels lake levels would rise above the long-

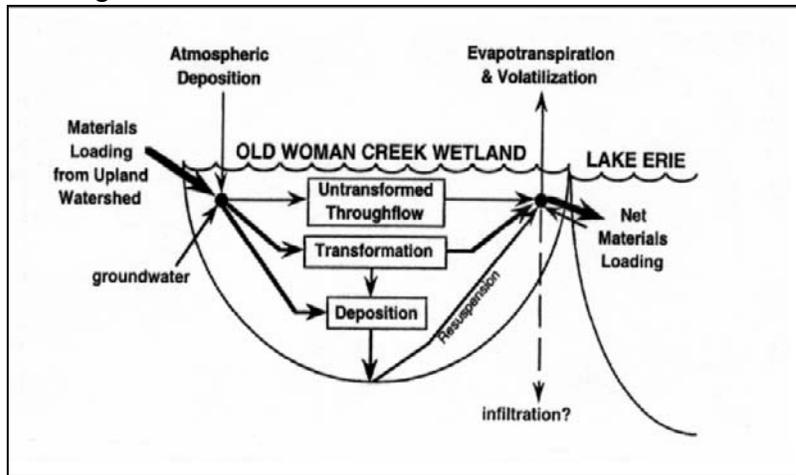


Figure 43: Conceptual model of materials fluxes in Old Woman Creek estuary wetlands (Krieger 2001).

term climate change levels. Some migration of coastal wetlands may be expected, but most of Lake Erie’s coastal wetlands will not be able to migrate lakeward due to man-made dikes or natural barrier beaches.

WATER RESOURCES

WATERSHED HYDROLOGY

Stream Hydrology. Old Woman Creek upstream above its estuary, is characterized by a continual movement of water, dissolved substances, and suspended particles, as well as bedload sediments during periods of high flow. These components are derived primarily from the stream’s watershed—the total land area draining into the channel of OWC. Hence, the hydrological, chemical, and biological characteristics of

OWC reflect the climate, geology, and vegetative cover of the watershed along with the human land use activities within the drainage basin.

Table 10. Physical attributes of streams and floodplain areas in the OWC watershed.

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| <p>CHANNEL AND FLOODPLAIN CONDITIONS</p> <ul style="list-style-type: none">Early Settlement Conditions— Oak-Beech-Maple Mixed Hardwood ForestPresent Channel Conditions— Free flowingPresent Floodplain Conditions— 61 structures in the floodplain (Assessed valuation???)Riparian Corridor Conditions (150ft buffer) — 74% Natural vegetation, 26% Cropland/UrbanFloodplain Connectivity— entrenchment has reduced floodplain usage in upper reaches <p>STREAM STATISTICS</p> <ul style="list-style-type: none">Forested Natural Riparian Buffer Coverage — 43% (east branch), 45% (west branch)Permanent Stream Protection— 3 milesNatural Channel<ul style="list-style-type: none">Never Modified— 14.8 milesFully Recovered— < 15 miles (estimated)Dams (number & height)— 0Channelization or Modified Channel— 31.8 miles (estimated)Stream Segments with Unrestricted Livestock Access— 4 operations, 1.6 miles of accessEroding Banks—1.5 miles (observed)Riparian Levees— 0 <p>POINT SOURCES</p> <ul style="list-style-type: none">Permitted Discharges—1-Berlin Heights (package plant at Berlin-Milan Schools)Spills and Illicit Discharges— N/A <p>NON POINT SOURCES</p> <ul style="list-style-type: none">Domestic Sewage Treatment—HSTS, no municipal treatment availableConcentrated Animal Feeding Operations— 0Highly Erodible Soils— 832 acresPotentially Highly Erodible Soils – 2,735 acresPetition Ditches—Huff Road Ditch, No.112 – 1300 l.ft.; Layne Tile, No 48; Bartow-Griffin No. 223 – 1150 l.ft. |
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Water in the tributary channel in the watershed originates from: (1) direct precipitation, (2) overland or sheet runoff, and (3) subsurface flow. When water is added to surface of the watershed's soil at a rate that exceeds the soil's infiltration capacity, it runs overland as sheet flow. Overland runoff, plus water that soaks into the soil and flows laterally to the stream channel are the main components peak flow or floods. Permeable soils tend to become saturated with water below a certain depth. The surface of this saturated zone is known as the water table; water in the soil above the water table is termed vadose water while that below is called groundwater. During the dryer portions of the year, groundwater provides a relatively stable base flow component in OWC. Average flow velocities in OWC are relatively low, generally less than 0.1 foot/second even in months of above average precipitation; but these velocities can accelerate to greater than 1.0 foot/second during storm events (Buchanan 1983). Annually, the flow rate of OWC water to the estuary averages about 15 cubic feet/second.

Worthy (1980) constructed a hydrograph for predicting runoff in the OWC drainage basin. He used a watershed area of 30 square miles, an average drainage area slope equal to 25.7 feet/mile, and a basin length of 8.8 miles. From the hydrograph, he determined that a storm of 6-hours duration and 1.7 inches of rainfall would yield a peak discharge of 646 cubic feet/second. The peak discharge would occur in the creek 4.2 hours following the storm. Such a storm has a 5-year return period for the OWC watershed.

Because of higher-than-average water levels in Lake Erie from the mid-1970s to the late 1990s, former marshlands, became inundated. This condition resulted in the flooding of approximately 150 acres adjacent to the estuary, extending lake level some 1.3 miles upstream. Historically, Lake Erie has exhibited extended periods of high and low water levels, which have caused the estuary to alternately flood and be exposed. Commensurate with the lowering of levels in Lake Erie in the late 1990s, much of the inundated OWC estuary once again developed an extensive emergent marsh.



Figure 44: Low flow in Old Woman Creek during summer months. Flow is representative of groundwater influence. (Hohman)

Sediment Discharge. The lower reaches of OWC and the estuary are turbid throughout most of the year, owing to the silty nature of the soil and sediment resuspension by wind and lake action. Buchanan (1983), using a drainage basin



Figure 45: Harvesting corn. (ESWCD)

area of 26.8 square miles, estimated the average water discharge into the estuary at 15.2 cubic feet/second or 0.57 cubic feet/second/square mile. Based on an average concentration of 0.1 grams/liter of suspended sediment along the length of the creek, he estimated that 21.2 grams/cubic foot/second enters the estuary. Within the estuary he found the average concentration of suspended sediment to be only 0.02 grams/liter or equivalent to 2.4 tons. Buchanan's estimates indicate a retention time calculation of 7.3 days for water in the estuary based on precipitation records. This value compares favorably with a flushing

rate calculation of 8.5 days based on the water budget presented by Mitsch et al. (1989) and the estuary volume obtained by Herdendorf and Hume (1991). By extrapolating a surface inflow coefficient from the Sandusky River basin (0.027 cubic

feet/sec/square mile), one obtains an average discharge rate of 5.3 cubic feet/second for OWC estuary, which is equivalent to a flushing rate of 11.2 days.



Figure 46: Example of agricultural run-off from plowed field. (ESWCD)

Woods (1987) studied OWC under storm conditions and measured a maximum discharge from OWC to the estuary of 151.8 cubic feet/second and a maximum sediment transport to the estuary of 411 grams/sec for a brief period. He found that high discharges were not necessarily associated with high sediment concentrations. Land use activities, such as field preparation in the spring and cropping in the fall, affected sediment concentrations in OWC.

Worthy (1980) concluded that the supply of sediment from the watershed does not have a significant effect on the stability of OWC inlet. He found that the sediment being transported through the estuary was largely silt-and-clay-sized material, whereas the barrier beach is composed of medium sand, derived from erosion of adjacent lake bluffs. Using data from the Sandusky River watershed (30 miles to the west), he extrapolated average suspended sediment load of 0.64 tons/day for OWC. Thus, about 234 tons of sediment is transported to the estuary annually. He speculated that seiche activity keeps the estuary agitated and the sediment suspended and that the bulk of this material is carried through the inlet during periods of high flow when the inlet is stable (open).

GROUNDWATER

Subsurface Drainage Area. Subsurface flow may have different boundaries (phreatic divides), particularly in areas underlain with soluble or permeable deposits (Wetzel and Likens 1979). This is the case for OWC where the subsurface drainage basin is dramatically larger than the surface watershed by virtue of a major glacially buried valley that underlies the estuary and extends over 40 miles to the south. Preglacial bedrock topography was used to define the boundaries of the subsurface drainage basin. This yields a potential subsurface drainage area of approximately 965 square miles. Because the bedrock floor of the preglacial valley lies some 125 feet below the bed of the estuary, it is likely that much of the groundwater flow in the buried valley is beneath the creek channel and therefore does not influence the hydrologic regime of OWC. However, if the elevation of deepest part of the channel in the estuary is extended laterally until bedrock is encountered, a more reasonable estimate is obtained for a subsurface drainage area that interacts with OWC estuary. This effective subsurface drainage area is approximately 40 square miles.

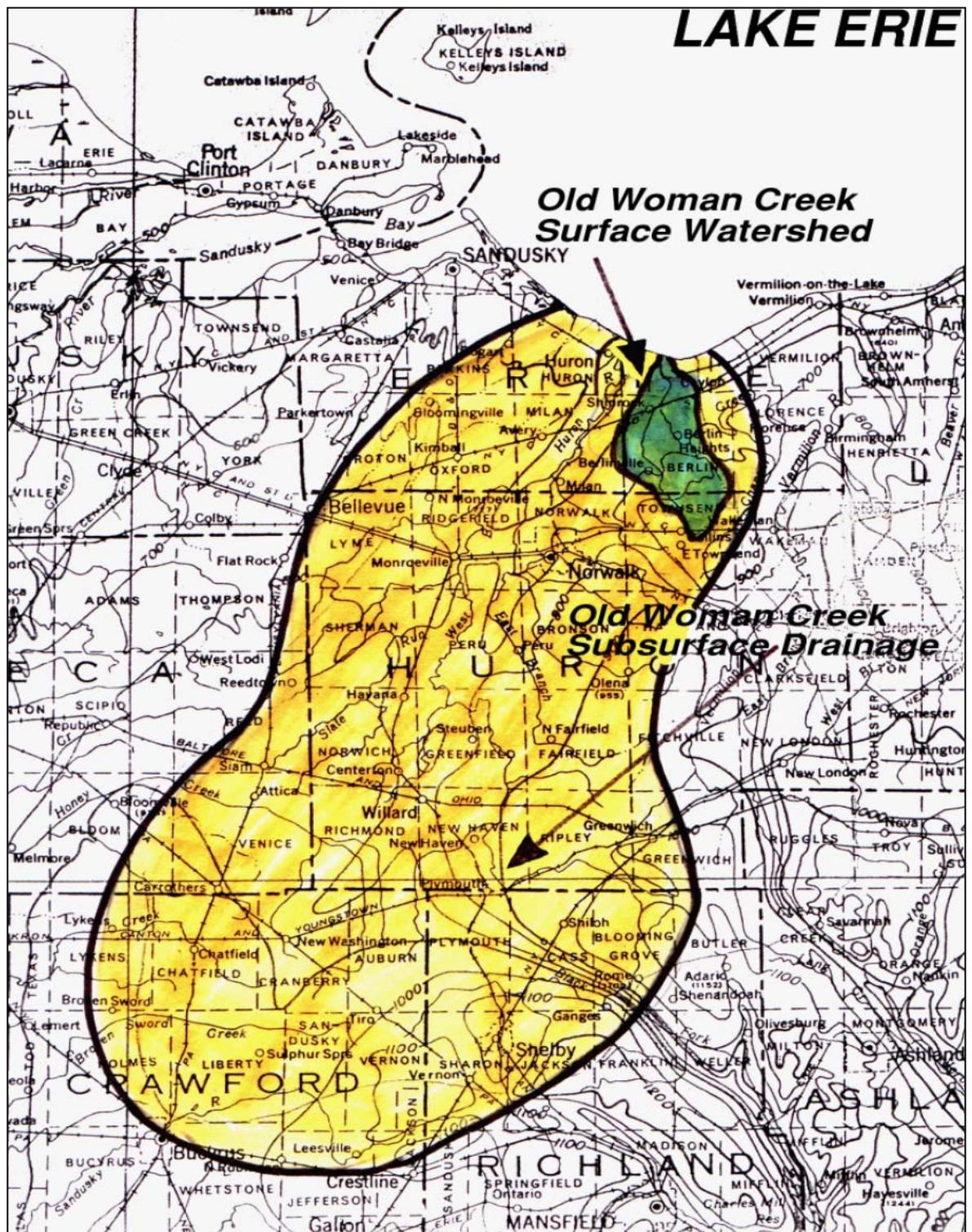


Figure 47: Subsurface drainage area for Old Woman Creek watershed, Herdendorf et al. 2004.

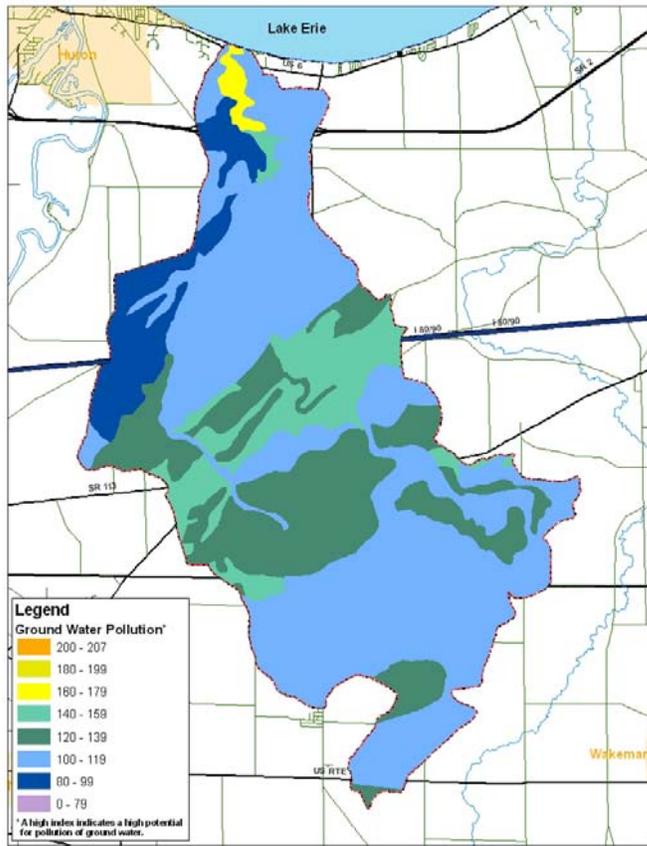


Figure 48: Ground water pollution potential in the OWC watershed. (ODNR)

Groundwater Hydrology. Within OWC, watershed groundwater is present in pore spaces in sandstone, joints and fractures in shale, and between the grains of sand and gravel. Groundwater supplies wells, keeps streams flowing during dry periods, and saturates certain soils to sustain wetland vegetation. Groundwater yields in the watershed can be classified into three zones (Stein 1962a,b). In the vicinity of the estuary (from the lakeshore south to Ohio Route 2), yields are relative high at 25 to 100 gallons per minute. Groundwater is developed from several lenses of sand and gravel interbedded in thick layers of clay. The preglacial valley that trends to the southwest under the estuary has been penetrated by water wells drilled to 125 feet without reaching bedrock. Such wells generally stop in sand and gravel lenses, which are good

producers of groundwater. From Ohio Route 2 south to Berlin Heights and then southwest to the Huron County line, groundwater yields are poor at less than 5 gallons per minute. Surface material in this zone is glacial drift, composed predominantly of clay, underlain by shale and some thin sandstone. Wells developed in the upper weathered portion of the bedrock yield an average of three gallons per minute. The remainder of OWC watershed south of Berlin Heights and into Townsend Township of Huron County has moderate groundwater yields ranging from five to 25 gallons/minute. In this zone sandstone and shale bedrock is covered with an average of 40 feet of glacial drift. Sandstone typically yields five to 20 gallons/minute at depths up to 130 f

Contamination Potential. The Ohio Department of Natural Resources, Division of Water has determined that the lower valley of OWC (surrounding the estuary) has the highest potential for groundwater pollution while, the higher ground portions of the watershed (remote from the estuary) have the lowest potential. This situation appears to be related to pollutants from agricultural sources that have a greater potential for infiltrating the groundwater in the generally slower moving estuary as compared to the more rapidly flowing upstream surface waters.

BIOTA

NON-VASCULAR PLANTS

The non-vascular plants of the OWC estuary and watershed include the algal flora and the lower plants. Algal flora are chlorophyll-bearing, aquatic organisms that lack vascular systems, true tissues, and root, stem, and leaf organs, while lower plants include the fungi, lichens, mosses, horsetails, and ferns—those aquatic and terrestrial plant-like organisms with less complex vegetative and reproductive morphology than the gymnosperms (conifers) and angiosperms (flowering plants).

Algal flora and lower plants found in the watershed embrace four of the five kingdoms of living organisms (Margulis and Schwartz 1988). Within the OWC estuary and watershed a total of 682 algal species and 648 lower plant species have been reported.

Table 11. Summary of algal flora and lower plants found in the vicinity of OWC watershed.

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| <p>ALGAL FLORA Algae: 682 species Kingdom Monera – 49 species Cyanobacteria (blue-green algae) – 49 species Kingdom Protista (plant-like) – 633 species Rhodophytes (red algae) – 1 species Chrysophytes (golden & yellow-green algae) – 351 species Chrysophyceae (golden-brown algae) – 32 species Xanthophyceae (yellow-green algae) – 6 species Bacillariophyceae (diatoms) – 313 species Pyrrhophytes (fire algae) – 10 species Cryptophytes (cryptomonads) – 21 species Euglenophytes (euglenoids) – 77 species Chlorophytes (green algae) – 173 species</p> <p>LOWER PLANTS Kingdom Fungi – 470 species Myxomycetes (slime molds) – 50 species Phycomycetes (algal fungi & water molds) – 61 species Ascomycetes (yeasts, molds & cup fungi) – 52 species Basidiomycetes (mushrooms & rusts) – 147 species Deuteromycetes (imperfect fungi) – 49 species Mycophycophytes (lichens) – 111 species Kingdom Plantae – 178 species Bryophytes (mosses & liverworts) – 156 species Lycopodiophytes (clubmosses) – 2 species Equisetophytes (horsetails) – 2 species Filicophytes (ferns) – 18 species</p> |
|---|

Cyanophyta (blue-green algae). Most of the blue-greens identified in OWC estuary are planktonic and are either spherical-shaped members of the family Chroococaceae (e.g., *Microcystis* and *Coelosphaerium*) or unbranched, filamentous forms (e.g., *Anabaena* and *Oscillatoria*) in several families. Representative species from OWC and its estuary are: *Aphanocapsa delicatissima*, *Chroococcus dispersus*, *Gomphosphaeria lacustris*, *Anabaena spiroides*, *Oscillatoria agardhii*, and *Oscillatoria limosa*.

Rhodophyta (red algae). Red algae are dominantly marine and are only sparsely represented in freshwater. One species, *Bangia atropurpurea*, occurs as short tufts or dense mats on partially submerged rocks near the splash zone along Lake Erie shore. The simple, unbranched filaments are brownish purple in color and appear in late spring to early summer, but disappear by mid-summer.

Chrysophyta (golden & yellow-green algae). This division of algae consists of three important classes: Chrysophyceae (golden-brown algae), Xanthophyceae (yellow-green algae), and Bacillariophyceae (diatoms). Chrysophytes contain chromatophores that often produce a golden-brown coloration because of the high content of carotenoid and xanthophyll pigments. Representative benthic and planktonic species from OWC and its estuary are: *Chrysococcus* spp, *Kephyrion* spp, *Pseudokephyrion* spp., *Mallomonas acaroids*, and various *Dinobyron* species including *D. bavaricum* and *D. divergens*. Xanthophytes are often associated with substrates, many being epiphytic on macrophytes but a few are planktonic. Although this group of algae is not well represented in OWC and its estuary, *Ophiocytium capitatum* var *longispina* is often observed in the plankton of the estuary.

Class Bacillariophyceae (diatoms). Diatoms are one of the most important group of algae in the estuary and the most important algal group in Lake Erie's nearshore waters. Over 300 species of diatoms have been identified from these habitats. Although the majority of species are sessile and associated with littoral vegetation or bottom sediments, many are important in the phytoplankton. Both unicellular and colonial forms are common. The class is divided in two orders based on shape: (1) Centrales are centric diatoms with radial symmetry and (2) Pennales are pennate diatoms with bilateral symmetry. The cell wall (frustule) consists of two lid-like, silica valves which fit together one within the other. The siliceous frustule incorporated a variety of delicate and ornate structures that are useful as taxonomic characteristics. Within OWC, the attached species of *Gomphonema* spp, *Navicula* spp, and *Nitzschia* spp are most common. The most important benthic diatoms in the estuary are also species of *Navicula* spp. and *Nitzschia* spp. Within the plankton in the estuary, *Aulacosieira alpigena*, smaller species of *Cyclotella* including *C. atomus* and *C. meneghiniana*, and a variety of smaller *Nitzschia* spp are most common.

Pyrrhophyta (fire algae). This division is represented by the Class Dinophyceae (dinoflagellates). Dinoflagellates differ from other biflagellated algae in having one of the two flagella circumscribing the body in a transverse groove or "girdle" while the other extends from the girdle posteriorly through a narrower groove. In most species

the body is armored with thick cellulose plates ranging in color from reddish-brown to yellow, which form a case or theca. The shape and number of these plates are an important taxonomic character for species identification. A common Lake Erie planktonic dinoflagellate is the genus *Ceratium*, which has a shape that often resembles the Eiffel Tower. The genus *Gymnodinium*, which at times reaches bloom proportions in the estuary, has green chromatophores, but lacks a distinct protective cellulose theca. Except for a brief period during 1981 when *Gymnodinium aeruginosum* reached bloom proportions, Dinoflagellates have not been a major component in the algae of OWC estuary. Besides this one species of *Gymnodinium*, *Ceratium hirundinella* and *Perdiniopsis quadridens* are infrequently observed in the estuary.

Cryptophyta (cryptomonads). Cryptomonads are unicellular and motile by virtue of two anterior flagella. They are naked, in that they lack true cell walls, but possess distinct reservoir pockets and chloroplasts, which contain a variety of pigments ranging from olive brown to blue to red. They comprise a common planktonic group in the estuary and Lake Erie. They can be particularly abundant in the winter months under low light conditions. Common representatives include several species of *Cryptomonas* and *Rhodomonas*. Cryptomonads are an important group in the estuary as *Cryptomonas erosa*, *C. ovata*, and *Rhodomonas minuta* var *nannoplanctonica*, often present in large numbers through the spring and summer.

Euglenophyta (euglenoids). Euglenoid algae are unicellular flagellates that typically have grassy green chloroplasts and a reddish sigma (eyespot with photoreceptive function). They store carbohydrates as granules in specialized reservoirs. Few species are truly benthic, most are planktonic. Members of the genus *Trachelomonas* are housed in a self-secreted lorica which varies in shape depending on the species and environmental conditions. Representative species from OWC and its estuary are: *Euglena acus*, *E. oxyuris*, *Phacus caudatus*, *Strombomonas longicauda*, *Trachelomonas volvocina*, *T. oblonga*, and *Lepocinclis ovum*.

Chlorophyta (green algae). Chlorophytes represent a large and diverse group of algae in the estuary and includes both benthic and planktonic forms. Green algae are a major component of the phytoplankton and includes such common genera as *Ankistrodesmus*, *Chlamydomonas*, *Closterium*, *Scenedesmus*, and *Pediastrum*. Filamentous, benthic forms of green algae include *Cladophora* and *Ulothrix*. The cell walls of green algae, like those of vascular plants, are composed cellulose and pectins. In some species, the walls are encrusted with calcium carbonate, silica, and other minerals such as iron oxides. The body plan of greens shows a great range of organization, including unicellular, colonial, filamentous, membranous (sheetlike), and tubular types. Representative species from OWC and its estuary are: *Chlamydomonas globosa*, *Ankyra judayi*, *Pediastrum simplex* var *simplex*, *Lagerheimia genevensis*, *Oocystis lacustris*, *Scenedesmus opoliensis*, *Cladophora glomerata*, and *Spirogyra* sp.

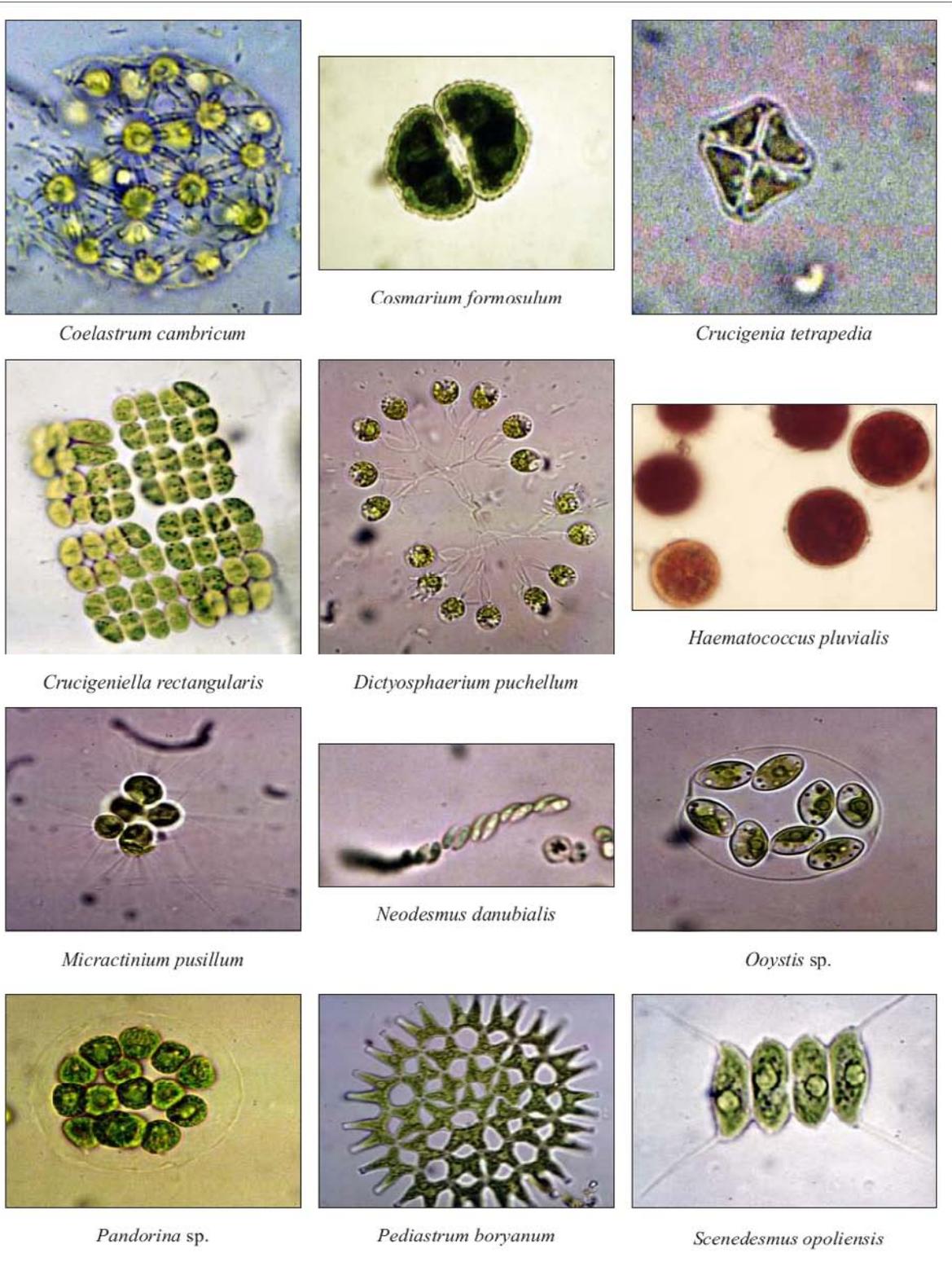


Figure 49: Representative planktonic green algae from Old Woman Creek estuary. (Klarer)

Lower Plants. Although most groups of lower plants are active in the fixation of carbon and the building of more complex organic molecules through the process photosynthesis, bacteria and fungi also perform the equally vital breakdown of organic matter. Without these recycling organisms, the land and waters of the watershed would rapidly become choked with debris that could only be decomposed slowly by chemical processes. Many of the environmental processes that we think of as purely chemical are mediated by microorganisms, such as the formation of rust (iron oxidation) can be facilitated by the bacteria *Leptothrix*—a common form in freshwater marshes. While bacteria tend to invade any organism as soon as it dies or is damaged, fungi, because they are larger and slower growing, are often secondary invaders. Saprophytic fungi, those growing on dead material, are thus the most numerous. Fundamentally, fungi are plant-like organisms that lack chlorophyll, cilia, or flagella (except some chytrids and oomycetes), and that form spores. Many construct a complex, interweaving mass of the fungal hyphae (filamentous threads that make the body of a fungus) in upland habitats, while unicellular species occur in the sediments of the watershed, releasing fungal spores or fragments into the water and air.

Myxomycetes (true slime molds). Slime molds are "animal-like plants" found in freshwater, in damp soil, and on rotting vegetation, particularly in woodlands on fallen logs. Over 50 species of Myxomycetes have been reported for the region surrounding the watershed.

Phycomycetes (algal fungi & water molds). Members of this division of fungi are believed to be derived from algal progenitors which had lost their chlorophyll. As a result, phycomycetes have assumed a parasitic or saprophytic mode of life. Over 40 species of both parasitic and saprophytic water molds have been reported for western Lake Erie.

Ascomycetes (bladder fungi). This division contains many familiar forms of fungi, such as yeast, fruit molds, morels, and truffles, as well as most of the fungal partners in lichens and other diverse parasitic and pathogenic forms. Members are known by one distinguishing feature, the ascu—a saclike structure containing the spores. Some of the spore-producing fruiting bodies are large and edible, such as the morel, or sponge mushroom.



Figure 50: The common morel (*Morchella esculenta*) (Herdendorf et al. 2004)

Basidiomycetes (small base fungi). Basidiomycetes are the most advanced division of fungi and can be distinguished from all others by the basidium—a microscopic clublike reproductive structure (spore producer) from which their name is derived. This division contains all of the woody fungi and nearly all of the large fleshy forms, including all but a few of the edible and poisonous mushrooms. The division also includes rust and smut fungi.

Deuteromycetes (imperfect fungi). The imperfect fungi is an artificial division characterized by the absence of a sexual state, in which both Ascomycota-like mycelium and Basidiomycota-like mycelium are represented, but species can not be placed in either of these divisions because their sexual state is not known. Most of the fungi that are pathogenic for humans are deuteromycetes.

Mycophycophytes (lichens). Lichens constitute a special group of thallophytes (plant body not differentiated into roots, stems, and leaves), in that they are a symbiotic association of a fungus and an alga. The algal member is usually a blue-green or green alga and the associated fungus is most commonly an ascomycete, although a few lichens have a basidiomycete component. Lichens typically grow on tree trunks, rocks, and moist soil. They occur as dry crusty patched (crustose), leaflike scales (foliose), or erect, branched tufts (fruticose), and their colors range from gray-green, yellow-orange, brown, and white to black. The dotted twig lichen, *Ramalina farinacea*, which had been reported for Erie County, is now considered extirpated in the State of Ohio.

Bryophytes (mosses & liverworts). The remaining "lower plants" are all true plants in that they develop from an embryo and are multicellular. Within the plant kingdom there are two basic groups: the bryophytes (nonvascular plants) and the tracheophytes (vascular plants). Bryophytes are intermediate between algae and the higher plants. They have hair-like rhizoids that function as roots, but lack true vascular tissue. Most are rather inconspicuous plants growing in moist environments. Although no detailed study of the bryophytes has been undertaken in the OWC watershed, 156 different species have been reported from the region, including *Barbula indica* var *indica* (twisted teeth moss), a listed rare plant in Ohio. Both Philips (1997) and Whyte (1996) have reported bryophyte species from the OWC watershed.

Lycopodiophytes (clubmosses). The clubmosses are relicts of the ancient scale trees that once dominated the landscape during the latter part of the Paleozoic era and eventually became fossilized into the coal measures of southeastern Ohio. Modern lycopods are relatively inconspicuous and represented by a single genera, *Lycopodium*, in the vicinity of the OWC watershed. This common clubmoss remains green all winter and has the appearance of a miniature pine tree.

Equisetophytes (horsetails). Horsetails are easily recognized by their jointed, hollow stems and rough, ribbed texture. The roughness is caused by mineral silica concentrated in the epidermal cell of the green photosynthetic stems. The abrasive nature imparted by the silica accounts for another common name for these plants, scouring rush. The division is made up of a single herbaceous genus, *Equisetum*. They thrive on mud flats, along the banks of streams, in moist low wooded areas. In the watershed, horsetails grow along the barrier beach and in the prairie remnant located southwest of the estuary's main basin.

Filophytes (ferns). Ferns are vascular plants of the woodlands that, like the bryophytes, lycopods, and equisetophytes, reproduce by means of spores, rather than seeds. Unlike the other lower plants, ferns do have leaves, called megaphylls or fronds, that develop directly from the main photosynthetic stem. Because their fertilization also requires the swimming of the sperm cell, ferns are limited to habitats that are at least occasionally moist. A total of 18 species of species of ferns in 6 families occur within the OWC watershed.

VASCULAR PLANTS

Higher vascular plants possess a well-developed conductive system, structural differentiation (typically roots, stems, and leaves), and seeds. Higher plants are grouped into two divisions based on seed characteristics. Within the OWC watershed, eight species of conifers (gymnosperms) and 829 species of flowering plants (angiosperms) have been reported.

Pinophytes (gymnosperms or conifers). A trait common to all gymnosperms is the absence of a protective case (ovary wall) around their seeds. This division is represented in the watershed by several native and alien pines (e.g., *Pinus strobus* and *Pinus nigra*) and eastern hemlock (*Tsuga canadensis*) in the ravine at Berlin Heights. In pines and other cone-bearers, seeds are borne on the surface of scales that comprise the cone, and although well-protected by the scales, they are not surrounded by floral part(s).

Magnoliophytaes (angiosperms or flowering plants). The majority of vascular terrestrial plants in the watershed are angiosperms, many of which produce attractive flowers. The seeds of these plants are borne within a closed structure (ovary) which eventually becomes the fruit. The flowering plants are subdivided into two classes based on the embryo's seed leaves (called cotyledons). In the monocots (class Liliopsida), a single narrow leaf first pierces the soil and stands erect (e.g., grasses, lilies, and orchids). In the dicots (class Magnoliopsida), which is the more common class, two broad leaves fall open as soon as they reach the soil surface with a seedling emerging from between them (e.g., most annuals, bushes, and trees). A total of 837 terrestrial and aquatic taxa of vascular plants have been identified in the watershed. About 78% are native species and 22% are aliens.

Table 12. Summary of vascular plants found in the OWC watershed.

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| Kingdom Plantae – 837 species | |
| Subkingdom: Tracheophyta (Vascular plants) | |
| Division: Coniferophyta | |
| Pinaceae (pines) – 6 species | |
| Taxodiaceae (bald cypresses) | |
| Division: Magnoliophyta | |
| Magnoliaceae (magnolias) | Rhamnaceae (buckthorns) |
| Lauraceae (laurels) – 2 species | Vitaceae (grapes) – 3 species |
| Saururaceae (lizard's tails) | Polygalaceae (milkworts) |
| Aristolochiaceae (birthworts) | Staphyleaceae (bladder-nuts) |
| Nelumbonaceae (lotus-lilies) | Hippocastanaceae (horse-chestnuts) |
| Nymphaeaceae (water-lilies) – 2 species | Aceraceae (maples) – 5 species |
| Ceratophyllaceae (hornworts) | Anacardiaceae (cashews) – 3 species |
| Ranunculaceae (buttercups) - 19 species | Oxalidaceae (wood sorrels) – 2 species |
| Berberidaceae (barberries) – 3 species | Geraniaceae (geraniums) |
| Menispermaceae (moonseeds) | Limnanthaceae (meadow-foams) |
| Papaveraceae (poppies) | Balsaminaceae (jewelweed) – 2 species |
| Fumariaceae (fumitories) | Aplaceae (carrots) – 9 species |
| Plantanaceae (plane-trees) | Gentianaceae (gentians) – 3 species |
| Ulmaceae (elms) – 3 species | Apocynaceae (dogbanes) – 2 species |
| Moraceae (mulberries) | Asclepiadaceae (milkweeds) – 4 species |
| Urticaceae (nettles) – 6 species | Solanaceae (nightshades) – 3 species |
| Juglandaceae (walnuts) – 4 species | Convolvulaceae (morning-glories) – 2 species |
| Fagaceae (Beeches) – 7 species | Custutaceae (dodders) – 2 species |
| Betulaceae (birches & hazlenuts) – 3 species | Polemoniaceae (phloxes) |
| Phytolaccaceae (pokeweeds) | Hydrophyllaceae (waterleafs) |
| Nyctaginaceae (four-o'clocks) | Boraginaceae (borages) |
| Chenopodiaceae (goosefoot & pigweed) – 3 species | Verbenaceae (vervains) – 4 species |
| Amaranthaceae (amaranth) – 3 species | Plantaginaceae (plantains) |
| Portulacaceae (purslanes) – 2 species | Oleaceae (olives) – 3 species |
| Caryophyllaceae (Pinks) – 5 species | Lamiaceae (mints) – 17 species |
| Polygonaceae (Buckwheats) – 15 species | Scrophulariaceae (figworts) – 14 species |
| Clusiaceae (Garcinias) – 3 species | Bignoniaceae (bignonias) – 2 species |
| Tiliaceae (lindens) | Camplanulaceae (bluebells) – 4 species |
| Malvaceae (mallows) – 3 species | Rubiaceae (madders) – 7 species |
| Cistaceae (rockroses) | Caprifoliaceae (honeysuckles) – 10 species |
| Violaceae (violets) – 6 species | Valerianaceae (valerians) – 2 species |
| Salicaceae (willows) – 8 species | Dipsacaceae (teasels) |
| Capparaceae (capers) | Asteraceae (composites) – 78 species |
| Brassicaceae (mustards) – 14 species | Butomaceae (flowering rushes) |
| Ericaceae (heaths) | Alismataceae (water plantains) – 3 species |
| Primulaceae (primroses) – 3 species | Hydrocharitaceae (frog's bites) |
| Hydrangeaceae (hydrangea) | Potamogetonaceae (pondweeds) – 4 species |
| Grossulariaceae (gooseberries) – 2 species | Acoraceae (sweetflags) – 2 species |
| Crassulaceae (orpines) | Araceae (arums) – 3 species |
| Saxifragaceae (saxifages) – 2 species | Lemnaceae (duckweeds) – 3 species |
| Rosaceae (roses) - 27 species | Commelinaceae (spiderworts) – 2 species |
| Caesalpiniaceae (caesalpinias) – 2 species | Junaceae (rushes) – 4 species |
| Fabaceae (peas) – 19 species | Cyperaceae (sedges) – 43 species |
| Elaeagnaceae (oleasters) | Poaceae (grasses) – 36 species |
| Haloragaceae (water milfoils) | Sparaganiaceae (bur-reeds) |
| Lythraceae (loosestrifes) – 3 species | Typhaceae (cattails) – 3 species |
| Onagraceae (evening primrose) – 6 species | Ponterderiaceae (pickeralweeds) |
| Cornaceae (dogwoods) – 6 species | Liliaceae (lilies) – 13 species |
| Santalaceae (sandalwoods) | Iridaceae (irises) – 4 species |
| Celestraceae (staff-trees) – 2 species | Smilacaceae (catbriers) |
| Aquifoliaceae (hollies) | Dioscoreaceae (yams) – 2 species |
| Euphorbiaceae (spurges) – 4 species | Orchidaceae (orchids) – 3 species |

Wetlands. The largest concentration of wetlands in the watershed is found near the estuary of OWC. The estuary is comprised of three major wetland habitats: (1) open waters of the basins, (2) embayments, mudflats, and low shorelines, and (3) swamp forests. These habitats contain distinct zones of vegetation. These zones contain plants of similar form and degree of adaptation to aquatic life. The relative proportion of the open water versus mudflat habitats is largely regulated by Lake Erie water levels.

The open waters of the estuary are characterized by dense, monotypic beds of *Nelumbo lutea* (American water lotus) which extend south from the US Route 6 bridge, through the main basin of the estuary, and into the south basin. In mid-1990s, *Nelumbo* beds covered up to 40% of the estuary surface during the peak growing season (Whyte 1996), whereas in the mid-1970s, lotus beds occupied only 10% of the estuary (Marshall 1977). Record high water levels in Lake Erie in the mid-1970s appear to be the cause of the sparse development of lotus beds during that period.

Other vascular, aquatic plants that are occasionally associated with the *Nelumbo* beds or occur in patches scattered throughout the open waters of the estuary include:

| | |
|--|--|
| <i>Ceratophyllum demersum</i> (coontail) | <i>Potamogeton crispus</i> (curly pondweed) |
| <i>Elodea canadensis</i> (common water-weed) | <i>Potamogeton foliosus</i> (leafy pondweed) |
| <i>Lemna minor</i> (lesser duckweed) | <i>Potamogeton nodosus</i> (knotty pondweed) |
| <i>Myriophyllum spicatum</i> (water milfoil) | <i>Potamogeton pectinatus</i> (sago pondweed) |
| <i>Nuphar advena</i> (yellow water-lily) | <i>Riccia fluitans</i> (crystalwort) |
| <i>Nymphaea odorata</i> (white water-lily) | <i>Ricciocarpus natans</i> (aquatic liverwort) |
| <i>Peltandra virginica</i> (arrow-arum) | <i>Spirodela polyrrhiza</i> (greater duckweed) |

The OWC estuary shoreline is characterized by steep banks that support dense growths of woody riparian vegetation. Common species, such as *Quercus alba* (white oak), *Quercus palustris* (pin oak), *Salix exigua* (sandbar willow), *Cornus florida* (flowering dogwood), *Cornus drummondii* (rough-leafed dogwood), *Cephalanthus occidentalis* (buttonbush), *Populus deltoides* (cottonwood), and *Vitis riparia* (river-bank grape), form a closed canopy which limits sunlight available to understory and shoreline emergent vegetation (Whyte 1996). The combination of a closed canopy and steep bluffs reduces the amount of habitat for the growth of emergent wetland vegetation to a narrow zone along the shoreline. Typical plants of this zone include: *Impatiens capensis* (jewel-weed), *Iris versicolor* (blue-flag), *Leersia orzyoides* (rice cut-grass), *Phalaris arundinacea* (reed canary-grass), *Pilea pumila* (clearweed), *Lobelia inflata* (Indian tobacco), *Ranunculus hispidus* (hispid buttercup), *Scutellaria lateriflora* (skullcap), *Solanum nigrum* (black nightshade), and *Carex* spp. (sedges). Along the base of the estuary bluffs and extending out into the open water, numerous fallen trees have accumulated debris to form micro-habitats with suitable substrate for herbaceous species such as *Setaria faberi* (foxtail-grass), *Carex comosa* (sedge), *Eclipta prostrata* (yerba-de-tajo), *Polygonum persicaria* (lady's thumb), and *Rorippa palustris* (common yellow cress).

From 1980 to 1999, the emergent flora was confined to the very shallow embayments in the estuary. However, the lower Lake Erie water levels after 1999 have resulted in extensive mudflat areas in the estuary, where there was open water a few years before. Marshall (1977) reported that the embayment areas had a high diversity, with many not having a distinct dominant species. Among the common species were: *Peltandra virginica*, *Leersia oryzoides*, *Phalaris arundinaceae*, *Calamagrostis canadensis*, *Typha latifolia*, *Sparganium eurycarpus*, and various *Scirpus* and *Carex* species. Whyte (1996) examined many of these embayments 20 years later and reported many of the same species. However, he reported that *Phragmites australis* was frequently found in this habitat.

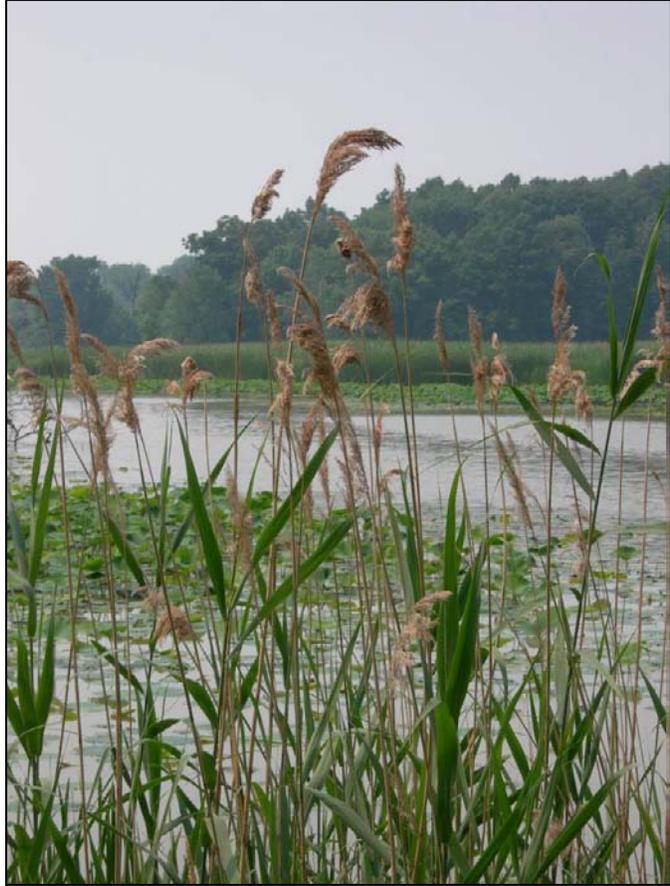


Figure 51: *Phragmites australis* is becoming more common in the estuary. (Elmer)

By 2000 with falling lake water levels, these shallow mudflat embayment areas accounted for a large portion of the estuary. The

grasses *Leersia oryzoides* and *Echinochloa* spp increased in importance from 2000 through 2001. *Phragmites australis* was also expanding its coverage during these two years. By 2002 *Phragmites australis* and *Typha angustifolia* had assumed dominance over much of the estuary (Herdendorf et al. 2004, 2006).

Along some reaches of the estuary shore (e.g., west bank north or Star Island), steep bluffs give way to open areas of low relief with associated mudflats and seasonally inundated floodplains. These areas support extensive monotypic colonies of *Phragmites australis* (common reed). With the exception of the climbing vines of wild cucumber (*Echinocystis lobata*), few other plants are associated with *Phragmites* stands. This reed is a recent invader, first appearing on the shores of the estuary in the mid-1980s (Whyte 1996).

Areas of swamp forest are found in two embayments along the east shore where seasonally flowing streams enter the estuary. A much larger lowland or swamp forest borders the southern reaches of the estuary. Common woody species in these areas are *Cephalanthus occidentalis* (buttonbush), *Fraxinus americana* (white ash), *Fraxinus pennsylvanica* (green ash), *Quercus rubra* (red oak), *Crataegus mollis* (downy hawthorn), *Cornus florida* (flowering dogwood), and *Viburnum acerifolium*

(arrowwood). Numerous herbaceous plants appear early in the growing season, including *Phalaris arundinacea* (reed canary grass) on, *Caltha palustris* (March marigold), *Ranunculus flabellaris* (yellow water buttercup), and *Anemonella thalictroides* (rue anemone). In total, 102 species of woody and herbaceous species have been reported for these wet woodlands (Windus 2002).



Figure 52: Swamp forest in the south estuary basin. Emergent beds of spatterdock (*Nuphar lutea*) in the foreground. (Wright)

Windus (2002) monitored the species composition and relative abundance in the swamp forest from 1987 through 2000. By 2000 the most common woody plants were *Fraxinus pennsylvanica*, *Cephalanthus occidentalis*, and then *Viburnum recognitum*. Through the duration of the sampling period, both *Fraxinus* and *Viburnum* declined in relative abundance while *Cephalanthus* remained about the same. The most common herbaceous plants included *Phalaris arundinacea*, *Polygonum* spp., *Sagittaria latifolia*, and less frequently *Typha* spp, *Scirpus fluviatilis*, and *Boehmeria cylindrical*. Many of the native species reported in the early years of this study have declined including the woody plants *Salix*, *Populus deltoides*, *Cornus sericea* and *Lindera benzoin*. These declines were believed related to declining water levels in the estuary.

Riparian Corridor Vegetation Characterization

Riparian corridors are essential in filtering pollutants from the water as well as in providing habitat to several species in the watershed. Often, a characterization of the watershed's corridor, in terms of the vegetative communities found within a determined buffer width, can better determine pollutant sources and identify areas

for BMP installation and protection. Using GIS mapping software, 2006 aerial photography of the watershed was analyzed to provide acreage totals for different vegetative communities found within 150 feet of the center line of stream (Figure 52). The buffer distance of 150ft was chosen so that, at a minimum, 100 feet of true buffer would be categorized when considering the center line of the stream may not depict actual stream width. Fifty to 100 foot buffers are considered a useful width for filtering out the highest amount of pollutant loading (sediment and nutrients and protecting many wildlife populations (Fischer and Fischenich, 2000).. **Table XX** shows the results of the GIS analysis for selected land cover types and other occurrences found within the OWC riparian corridor survey area. Seventy percent of the corridor has some vegetation (e.g., forest, herbaceous, shrubs).

Table 13. Vegetation Characterization of the OWC riparian corridor (150ft buffer).

| Category | Total Acres | Percent of Corridor |
|------------|-------------|---------------------|
| Cropland | 586.57 | 26 |
| Forest | 976.45 | 43 |
| Herbaceous | 537.39 | 23 |
| Shrub | 91.51 | 4 |
| Impervious | 37.89 | 2 |
| Open Water | 48.39 | 2 |



Figure 53: Excellent wooded corridor of Old Woman Creek. (Elmer)

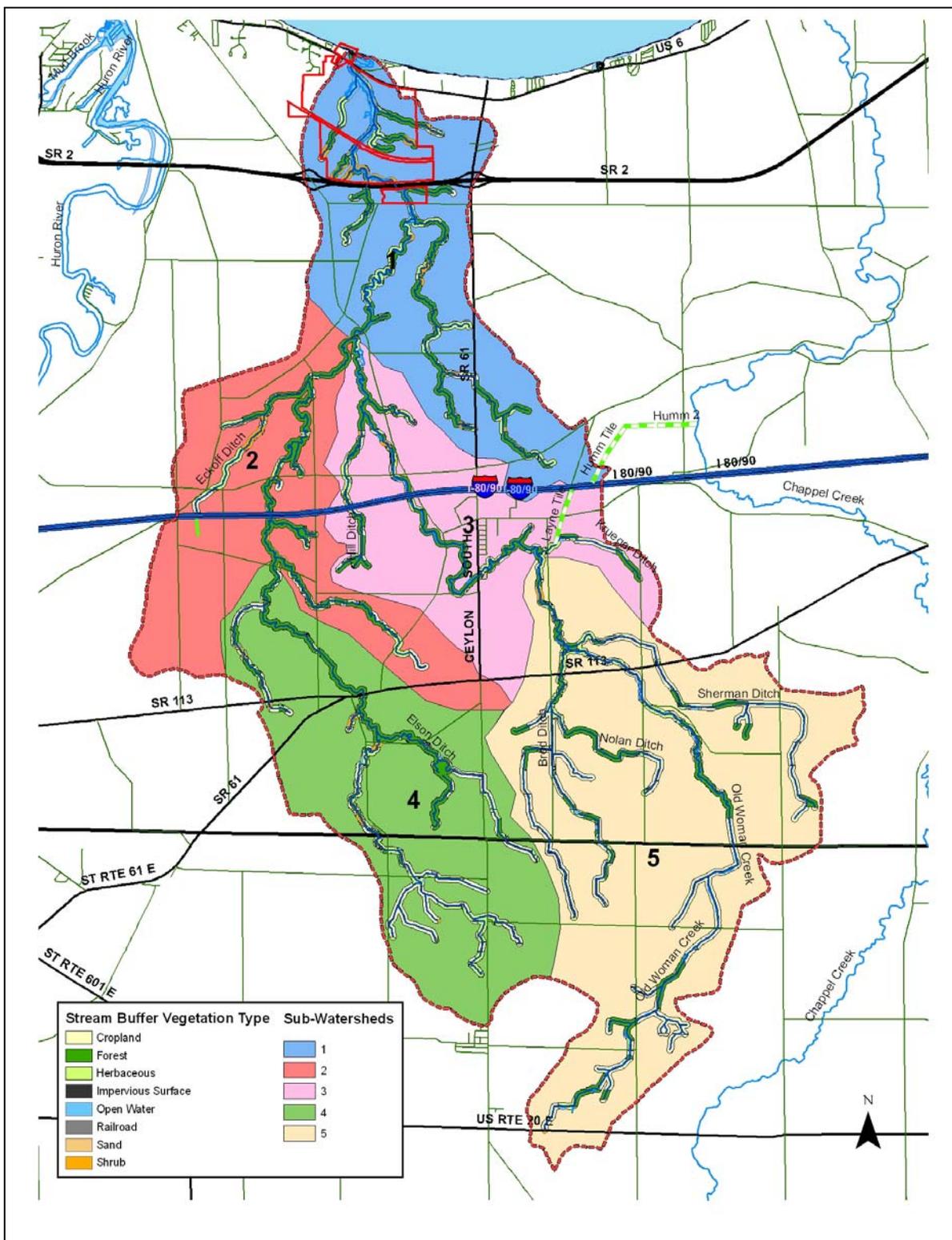


Figure 54: Riparian corridor vegetation characterization of Old Woman Creek showing vegetation categories within 150ft of the stream. (ODNR- Steve Barry)

INVERTEBRATE FAUNA

Invertebrate is the name given to any animals or animal-like organisms without backbones as contrasted with the vertebrates (e.g., fish, amphibians, reptiles, birds, and mammals), all of which have a vertebral column. Taxonomically, invertebrates are grouped into some 37 phyla in two kingdoms: Protista and Animalia. Representatives of 13 of the invertebrate phyla have been identified in the OWC watershed, and the adjacent waters and tributaries of Lake Erie. Altogether, a total of 1,352 species of aquatic and terrestrial invertebrates have been documented: 318 protozoans, 2 sponges, 2 hydroids, 5 flatworms, 2 gastrotrichs, 34 rotifers, 3 nematodes, 33 mollusks, 46 annelid worms and leechs, 77 spiders and water mites, 83 crustaceans, 741 insects, 1 tardigrades, and 5 bryozoans (Table X.X).

Protozoan Invertebrates. Protozoans consist of a large group of unicellular animals that have adapted their cell to serve as their entire body. Classified as a subkingdom of the Kingdom Protista, protozoans are not simple organisms. Within a single cell they must perform all of the body functions for which higher animals have many organ systems. The locomotor organelles of protozoans are used to separate them into major taxonomic groups. These organelles include: (1) undulipodia, which posses cilia or flagella and (2) pseudopodia, which are elongated extensions of the body formed by protoplasmic flows. Undulipodia produce rotary, undulatory, and helical wave motions that propel the cell, whereas pseudopodia create flowing motions. Protozoans live under almost all natural conditions where moisture is found. Within the OWC watershed, researchers have identified 212 undulipod species and 106 psudeopod species.

Animalia Invertebrates. All animalia invertebrates are heterotrophs, in that is they must obtain energy in the form of organic food produced by other organisms. Most of the distinctive characteristics of animals are associated with the requirements of finding, engulfing, and digesting food (Parker 1982). Animalia invertebrates from 11 phyla have been identified in the OWC watershed, altogether yielding 1,055 species.

Table 14. Summary of invertebrate fauna found in the vicinity of OWC.

| |
|---|
| Kingdom Protista: (animal-like Protozoans – 318 species) |
| Sarcomastigophora – (198 species) |
| Ciliophora – (120 species) |
| Kingdon Animalia (invertebrates – 1,055 species) |
| Phylum Porifera |
| Class Demospongiae (horny sponges–2 species) |
| Phylum Cnidaria |
| Class Hydrozoa (hydras–2 species) |

Phylum Platyhelminthes

Class Turbellaria (flatworms–5 species)

Phylum Gastrotricha

Class Chaetonotida (gastrotrichs–2 species)

Phylum Rotifera

Class Bdelloidea (rotifers–3 species)

Class Monogononta (rotifers–3 species 1)

Phylum Nematoda

Class Adenophorea (roundworms–3 species)

Phylum Mollusca

Class Gastropoda (snails–11 species)

Class Bivalvia (clams–22 species)

Phylum Annelida

Class Hirudinea (leeches–4 species)

Class Oligochaeta (segmented worms–42 species)

Phylum Arthropoda

Class Arachnida

Order Araneae (spiders–74 species)

Order Acariformes (water mites–3 species)

Class Crustacea

Subclass Branchiopoda

Order Cladocera (water fleas–39 species)

Subclass Ostracoda (seed shrimps–9 species)

Subclass Copepoda (water-hoppers species)

Order Calanoida (calanoid copepod–9 species)

Order Harpacticoida (harpacticoid copepod–4 species)

Order Cyclopoida (cyclopoid copepod–12 species)

Subclass Branchiura:

Order Arguloida (fish lice–1 species)

Subclass Malacostraca

Order Isopoda (sow bugs–2 species)

Order Amphipoda (scuds–4 species)

Order Decapoda (crayfishes & shrimps–3 species)

Class Insecta

Subclass Entognatha

Orders Collembola & Diplura (springtails & diplurans–4 species)

Subclass Ectognatha

Order Thysanura (bristletails–1 species)

Order Ephemeroptera (mayflies–21 species)

Order Odonata (damselflies & dragonflies–51 species)

Orders Blattaria & Mantodea (cockroaches & mantids–4 species)

Order Isoptera (termites–1 species)

Order Orthoptera (grasshoppers & crickets–15 species)

Order Dermaptera (earwigs–4 species)

Order Plecoptera (stoneflies–4 species)

Order Thysanoptera (thrips–3 species)

Order Hemiptera (true bugs–78 species)

Order Homoptera (cicadas, leafhoppers & aphids–32 species)

Order Neuroptera (nerve-wing insects–12 species)
 Order Coleoptera (beetles–179 species)
 Orders Mecoptera & Siphonaptera (scorpionflies & fleas–3 species)
 Order Diptera (true flies–127 species)
 Order Trichoptera (caddisflies–74)
 Order Lepidoptera (butterflies & moths–83 species)
 Order Hymenoptera (ants, bees & wasps–52 species)

Phylum Tardigrada

Class Eutardigada (water bears–1 species)

Phylum Bryozoa

Class Phylactoaemata (bryozoans–5 species)

VERTEBRATE FAUNA

Vertebrates are all members of the animal Phylum Chordata, Subphylum Vertebrata. Of the seven classes in this subphylum, six are found in OWC watershed and the adjacent region of Lake Erie: Agnatha (jawless fish), Osteichthyes (bony fish), Amphibia, Reptilia, Aves (birds), and Mammalia. Only the Class Chondrichthyes (cartilaginous fish – sharks and relatives) is absent. Members of this phylum possess the following characteristic features, at least during some stage of development: (1) a notochord (whence the name of the phylum is derived), a stout yet flexible rod-like structure running down the back of the trunk in the position occupied by the backbone in typical adult vertebrates, (2) a hollow dorsal nerve cord lying above the notochord, and (3) numerous gill slits, which open outward from the pharynx to the exterior. The notochord is prominent in the embryo in every vertebrate, but in the adult it is supplanted by the backbone– vertebral column to which the group owes its name.

The diversity of habitats within the OWC watershed contribute to a variety of plant and animal communities, each comprised of a distinctive fauna. A total of 121 fish, 27 amphibian, 25 reptilian, 370 avian, and 51 mammalian species have been identified in the watershed and adjacent tributaries and waters of Lake Erie.

Table 15. Summary of vertebrate fauna found in the vicinity of OWC.

VERTEBRATE FAUNA

Kingdon Animalia (vertebrates – 595 species)

Fishes: 121 species

Jawless Fishes (lampreys – 2 species)

Bony Fishes – (119 species)

Amphibians: (27 species)

Salamanders – 16 species

Frogs & Toads – 11 species

Reptiles: (25 species)
Turtles – (8 species)
Snakes – (17 species)

Birds: (370 species)

Mammals: (41 species)
Marsupials (opossums – 1 species)
Insectivores (moles & shrews – 5 species)
Bats – (8 species)
Carnivores – (9 species)
Rabbits – (1 species)
Rodents (squirrels, muskrats & mice – 14 species)
Ungulates (deer & bison – 2 species)
Primates (man – 1 species)

Fish (Classes Agnatha & Osteichthyes). Agnatids includes the lampreys, the lowliest of the vertebrates. These serpentiform fishes resemble eels superficially, but eels are highly developed bony fishes while lampreys have no bones, no trace of paired fins, nor biting jaws, one of the most significant structural features of all other vertebrates. Two species of lamprey have been collected by Trautman (1981) in Lake Erie off the mouth of OWC estuary. The osteichthids, or bony fishes, usually have jaws, bony vertebrae, paired fins, paired nostrils, scaled bodies, and a swim bladder. A total 119 species of bony fishes have been reported for OWC, adjoining watersheds, and the adjacent waters of Lake Erie. Within the estuary and watershed, 51 different fish species, in 2 classes, have been identified. Of the 51 species, 49 are reported from the estuary and 11 from the creek proper. None of the 23 fish species considered threatened or of special concern found in north central Ohio have been reported from the waters of OWC watershed.

Amphibians. This class of vertebrate animals includes salamanders, toads, and frogs. These animals are characterized by (1) a moist, glandular skin without scales, (2) toes that are devoid of claws, and (3) a larval stage that is usually aquatic. Most amphibians have four limbs that have evolved from ancestral lobe-finned fishes. This class is represented by 27 species of salamanders, toads, and frogs in the OWC watershed and adjacent waters of Lake Erie (Bernhardt 1985). An additional 11 species have been reported in nearby watersheds. The



Figure 55: Leopard frog (*Rana pipens*) on of the most abundant frogs in Lake Erie coastal wetlands. (Herdendorf, et al. 2004)

The salamanders found in the study area are of three types (families): (1) giant salamanders of which the aquatic and continually larval mudpuppy is a member, (2) mole salamanders of which the underground spotted

salamander and a hybrid form are resident, and (3) the lungless salamanders, which includes the dusky, two-lined, redback, slimy, ravine, and red salamanders. The toads and frogs in the watershed are also of three types (families): (1) dry, warty skinned toads of which American and Fowler's toads are members, (2) chorus frogs of which the spring peeper and western chorus frog are abundant, and (3) true frogs of which bullfrog, green frog, and leopard frog are present. Two amphibians listed as a species of special concern by the Ohio Division of Wildlife, *Hemidactylium scutatum* (4-toed salamander), *Acis crepitans* (eastern cricket frog) has not been found in the OWC watershed.

Reptiles. This class of vertebrates are clad in scales or plates, often possess toes with claws, and produce young that are miniature replicas of the parents. Reptiles are represented by 25 species of turtles and snakes in OWC watershed and the adjacent waters of Lake Erie. The turtles found in the watershed are of four types (families): (1) musk turtles, (2) snapping turtles, (3) box/water turtles, and 4) softshell turtles. The snakes in the watershed all belong to the colubrid family (or harmless snakes), the largest snake family in the world. The reptiles of the watershed are primarily known through the work of Bernhardt (1985). Four of the six reptiles listed as species of concern by the Ohio Division of Wildlife have been reported from the OWC watershed.

Birds (Class Aves). This class forms a very distinct vertebrate group, characterized by a series of special features, most of which are adapted for flight and life in the air. A total of 335 bird species have been reported in the OWC watershed. Some 125 of the species are considered to be migratory and are only passing through the region to travel to and from their breeding and/or wintering grounds. Of the 43 species that are listed as species of concern by the Ohio Division of Wildlife, all but one species, *Chondestes grammacus* (lark sparrow), have been sighted in the OWC watershed. Following a long period of absence, the bald eagle (*Haliaeetus leucocephalus*) has nested in the watershed since 1994.



Figure 56: Bald eagle (*Haliaeetus leucocephalus*). (ESWCD)

Mammals. As the name of this class implies, mammals nurse their young and in most cases bear them alive at an advanced stage of development, the young having been nourished within the mother's uterus. As in birds, a high body temperature is maintained, permitting continuous activity in a wide range of climatic conditions, especially terrestrial environments. The presence of hair or fur in many members aids in temperature maintenance. The brain is highly developed, particularly in regard to learning ability. A total of 51 species (15 families) of mammals have been reported from the region surrounding OWC. Of this number 28 species have been reported from studies within the OWC watershed. Patrick (1981) and Bernhardt (1985) have recorded most of the initial sightings from the OWC watershed.



Figure 57: Young red fox (*Vulpes vulpes*) (Herdendorf, et al. 2008)

RARE, THREATENED, AND ENDANGERED SPECIES

Four of the bivalve mollusks reported for the nearshore waters of Lake Erie in the vicinity of OWC are listed by the Ohio Division of Wildlife as threatened (T) or of special interest (S):

- Black sandshell (*Ligumia recta*) (T)
- Fawnsfoot (*Truncilla donaciformis*) (T)
- Deertoe (*Truncilla truncata*) (S)
- Purple wartyback (*Cyclonaias tuberculata*) (S)

No other invertebrates found within the watershed appear on the State list of rare, threatened, or endangered species. Of the 43 avian species that are listed as species of concern by the Ohio Division of Wildlife, all but one species, *Chondestes grammacus* (lark sparrow), have been sighted in the OWC watershed. The bald eagle (*Haliaeetus leucocephalus*) has nested in the watershed since 1994.

The diversity of ecosystems in the OWC watershed ranging from open upland to coastal wetlands have provided necessary niches for many rare and threatened species to inhabit, particularly native plants. The status list for rare native Ohio plants is revised every two years. State status is determined from records in the Natural Heritage Data Base.

Table 16. Ohio Listed Plant Species in the OWC Watershed

| Scientific name | Common name | State Status |
|---------------------------------|-------------------------------|------------------------|
| <i>Acorus americanus</i> | American Sweet-flag | Threatened |
| <i>Apocynum sibiricum</i> | Clasping-leaved Dogbane | Threatened |
| <i>Artemisia campestris</i> | Beach Wormwood | Endangered |
| <i>Cakile edentula</i> | Inland Sea Rocket | Potentially Threatened |
| <i>Carex appalachica</i> | Appalachian Sedge | Threatened |
| <i>Carex aquatilis</i> | Leafy Tussock Sedge | Potentially Threatened |
| <i>Carex bebbii</i> | Bebb's Sedge | Potentially Threatened |
| <i>Carex bicknellii</i> | Bicknell's Sedge | Threatened |
| <i>Carex lasiocarpa</i> | Slender Sedge | Potentially Threatened |
| <i>Carex retroflexa</i> | Reflexed Sedge | Potentially Threatened |
| <i>Cyperus schweinitzii</i> | Schweinitz' Umbrella-sedge | Threatened |
| <i>Euphorbia polygonifolia</i> | Seaside Spurge | Potentially Threatened |
| <i>Gymnocarpium dryopteris</i> | Common Oak Fern | Threatened |
| <i>Helianthemum bicknellii</i> | Plains Frostweed | Threatened |
| <i>Ranunculus fascicularis</i> | Early Buttercup | Potentially Threatened |
| <i>Sisyrinchium mucronatum</i> | Narrow-leaved Blue-eyed-grass | Endangered |
| <i>Spiranthes magnicamporum</i> | Great Plains Ladies'-tresses | Potentially Threatened |
| <i>Triplasis purpurea</i> | Purple Sand Grass | Potentially Threatened |

Source: Ohio Natural Heritage Database

AQUATIC AND TERRESTRIAL INVASIVE SPECIES

Throughout the Great Lakes, there is no ecosystem management issue more confounding than invasive species. The ballast water from lake-borne commerce is a prime pathway for the introduction of invasive species into the lakes and near shore areas. Over 180 documented aquatic invasive species have entered the Great Lakes with nearly three quarters of that total coming in since the St. Lawrence Seaway opened in 1959. Additional invasions happen on a monthly basis. Many of the species have detrimental impacts on coastal wetland areas like the OWC estuary.

Invasive Species found in the OWC watershed and Lake Erie

| | |
|----------------------|--|
| Emerald ash borer | <i>Agrilus planipennis</i> |
| Zebra mussel | <i>Dreissena polymorpha</i> |
| Quagga mussel | <i>Dreissena rostriformis bugensis</i> |
| Asiatic clam | <i>Corbicula fluminea</i> |
| Round goby | <i>Neogobius melanostomus</i> |
| Sea lamprey | <i>Petromyzon marinus</i> |
| Eurasian Ruffe | <i>Gymnocephalus cernuus</i> |
| Common (Giant) Reed | <i>Phragmites australis</i> |
| Purple loosestrife | <i>Lythrum salicaria</i> |
| Reed canary grass | <i>Phalaris arundinacea</i> |
| Garlic mustard | <i>Alliaria petiolata</i> |
| Multiflora rose | <i>Rosa multiflora</i> |
| Bush honeysuckle | <i>Lonicera mackii</i> |
| Japanese honeysuckle | <i>Lonicera japonica</i> |
| Common privet | <i>Ligustrum vulgare</i> |
| Autumn olive | <i>Elaeagnus umbellata</i> |
| Lesser celandine | <i>Ranunculus ficaria</i> |
| Japanese Knotweed | <i>Fallopia japonica</i> |

Among the many invasive species found within the watershed, invasive plant species appear to need the most consideration in terms of post-construction control efforts in restoration and stabilization projects. Aquatic invasives such as *Phragmites*, purple loosestrife, and reed canary grass are generally found in large areas within one mile of Lake Erie. OWC NERR has and will continue to prioritize the treatment of aquatic areas impacted by these invasives as part of their own management strategy of the Reserve area. In addition, garlic mustard, honeysuckle, autumn olive, multiflora rose and privet in upland areas will also be controlled, as resources permit.

LAND USE

The major land use in the OWC watershed is agriculture. The fertile silt and sand loam soils of the area, complimented by the prolonged growing season due to the "lake effect" are currently producing high yields of corn, soybeans, wheat, orchard fruit, and other produce associated with "truck farms." The economy of the area, however, is entering a transitional stage, as agricultural lands are being preempted by the outward growth of nearby cities.

Old Woman Creek Watershed at a Glance

USGS Hydrologic Unit # 04100012-040-020

Counties:

| | |
|-------|-------|
| Erie | 79.3% |
| Huron | 20.7% |

Ecoregions: Erie/Ontario Drift and Lake Plains (Lake Erie Plain) and Eastern Corn Belt Plains (Clayey High Lime Till Plains)

Watershed Size:

| | |
|----------------------|--------------|
| Total Acres | 17,280**est |
| Drainage Area | 27sq miles |
| Groundwatershed Area | 965 sq miles |

Stream length:

West Branch

- 1st Order Tributaries (No. 13; Total Length: 6.8 miles)
- 2nd Order Tributaries (No. 3; Total Length: 7.1 miles)
- 3rd Order Tributaries (No. 1; Total Length: 1.2 miles)

East Branch

- 1st Order Tributaries (No. 11; Total Length: 17.5 miles)
- 2nd Order Tributaries (No. 3; Total Length: 4.2 miles)
- 3rd Order Tributaries (No. 1; Total Length: 4.7 miles)

Main Stream & Estuary

- 1st Order Tributaries (No. 4; Total Length: 1.8 miles)
- 4th Order Tributaries (No. 1; Total Length: 3.3 miles)

Total length: 46.6 miles

Elevation:

| | |
|--------------|---------------------------------------|
| Source | 885 feet |
| Mouth | 575 feet |
| Total fall | 310 feet |
| Average fall | 21 feet/mile or 0.40% stream gradient |

Drains into Lake Erie approximately 3 miles east of city of Huron.

| Land Use Cover | % of Watershed |
|-----------------------|-----------------------|
| Urban | 8.5% |
| Agriculture | 65.7% |
| Transportation | 3.8% |
| Wooded/Forested | 20% |
| Open Water/wetlands | 1.7% |

Erie County

Villages:

Berlin Heights

Townships:

Berlin

Florence

Huron

Huron County

Townships:

Townsend

Wakeman

Special Districts and Land Conservancy Groups

Erie Soil and Water Conservation District

Huron Soil and Water Conservation District

Erie MetroParks

Berlin Milan School District

Western Reserve School District

Huron City School District

Western Reserve Land Conservancy

Erie Regional Planning

Northern Ohio Rural Water

Erie County Water Department

Phase II

Erie County is considered a Phase II community; however, there are no urbanized areas within the OWC watershed as defined by the 2000 Census.

Special Areas

Old Woman Creek State Nature Preserve

Edison Woods MetroPark

Huffman Reserve

Berlin Heights Gorge

Berlinville Gorge

TMDL Reported Impairments

- Sediment
- Excessive nutrients
- Habitat Loss

Water Resources Issues of Local Concern

- Water quality impacts associated with conversion and subdivision of agricultural land for residential uses
- Risk of altered, and/or lost sense of community resulting from decreased connection to natural resource
- Lack of land use planning involving citizen involvement and multi-community cooperation
- Inadequate or poorly functioning wastewater treatment systems

CULTURAL AND HISTORICAL ASPECTS

Archaeologists believe that the the ancestors of Native Americans spread into North America from Asia about 20,000 years ago. These first Americans moved south and east into what is now northern Ohio shortly after the last great continental glaciers retreated northward. By about 11,000 years ago, people called Paleo-Indians roamed the southern Great Lakes region, hunting mastodon (an extinct elephant), barren ground caribou, and probably other Ice Age animals.



Figure 58: Seasonal hunting camp typical of Archaic and Woodland Indians (Herdendorf, et al. 2004)

Lake Erie was already several thousand years old by this time, and people began to take advantage of the rich biological diversity among the plant and animal communities of the lakeshore. From this time on, people visited the OWC estuary, living off the rich bounty that it provided.

Old Woman Creek, which has been occupied off and on for the past 10,000 years, was attractive to people because of its well-drained sandy soil and its strategic location.

The site's location provided protected access through the estuary to the lake for fishing and commerce, and immediate entry to nearby upland forests with their rich harvest of plants and game.

Then, about three thousand years ago, the life of indigenous people in much of eastern North America began to undergo a fundamental change, partially in response to the cultivation of certain plants for food. Cultivated plant foods supplemented a subsistence economy based on hunting, gathering, and fishing, and by about A.D. 900, farmers became reliant on corn, beans, squash and sunflower for a significant portion of their food.

For nearly 10,000 years, humans developed and refined methods of successfully exploiting the environment for basic needs. Although lifeways changed significantly from the Paleo-Indians to Native Americans who made contact with European settlers in the late 1700's, the importance of natural resources in everyday life remained constant. Clay from the soil, plants of the wetlands and forests, fish, birds and mammals were essential to the survival of all these native cultures.

In 1795, the Greenville Treaty was signed between the United States and the Ohio Native American tribes. This act began an era that would see Native Americans lose all their Ohio lands to the United States government. In 1805, Almon Ruggles came to the OWC area to survey the land for the State of Connecticut. This territory was originally part of lands claimed by England as a result of the French and Indian War. Under a charter from the King of England, Connecticut laid claim to the

territory that included all of present-day Erie and Huron Counties, including the OWC watershed. Following the American Revolution, colonies were requested to cede their holdings of western land to the newly formed United States government. Connecticut agreed to turn over its colonial holdings except for one western tract reserved for the state. During the American Revolution, many residents of Connecticut had lost their property. In return for damages suffered (mainly by fire), the state agreed to give land to these citizens in lieu of monetary payment. In 1792, the westernmost 500,000 acres of the "Connecticut Western Reserve" was set aside as "The Firelands", to be divided among less than 2000 claimants.

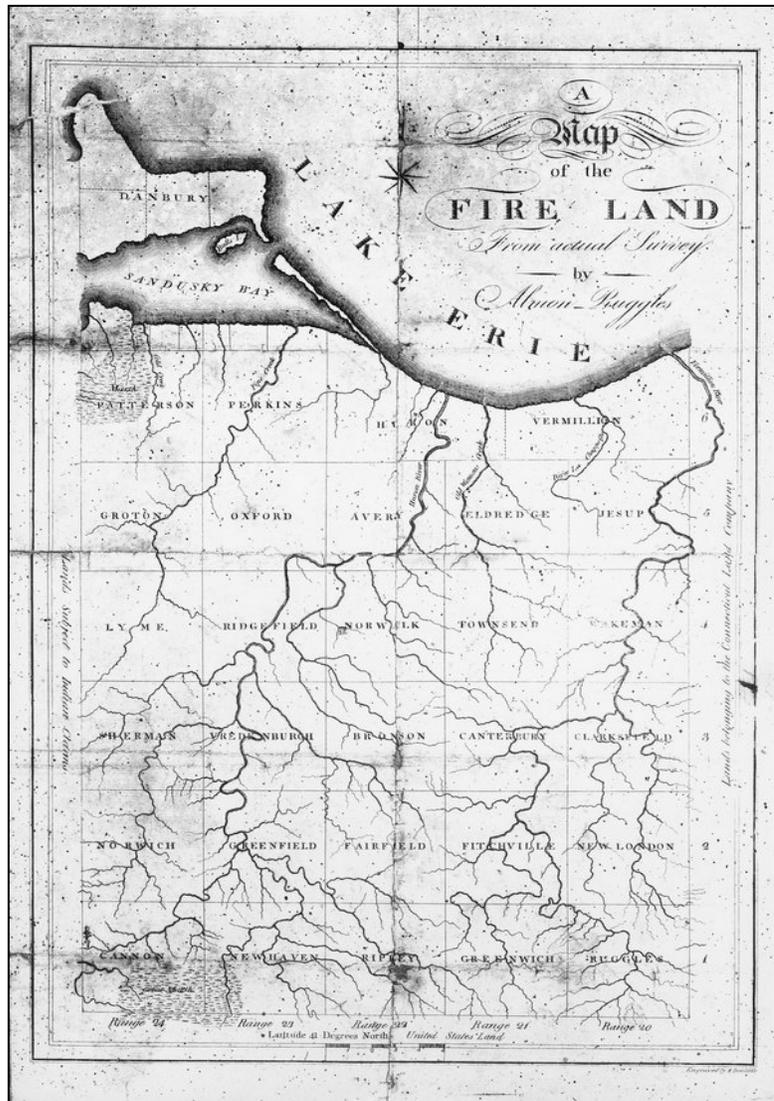


Figure 59: Copy of the "Fire Land" Map created by land surveyor Almon Ruggles for the State of Connecticut (1809 circa), Firelands Historical Society.

Historical records indicate that during the 18th century saw mills, sandstone quarries, grist mills and at least one salt well were situated within the OWC watershed. Small fruits such as strawberries, raspberries, and grapes were also introduced to this region throughout the next hundred years. Hardwood timber, particularly oak, was sought by the ship building industry in nearby Huron. Huron was the largest ship building site in Ohio in the middle 1800's.

By 1879, most of the land surrounding OWC had been cleared, timber removed, and ditches opened to drain agricultural lands. These factors contributed to annual flooding of the creek, rendering its flood plain "worthless" to farmers.

Historical Sites. Several historical sites can be found within the OWC watershed particularly surrounding the Village of Berlin Heights, which was once a bustling town that boasted an interurban railroad which connected the Berlin Heights community with other communities along the Lake Erie shores.

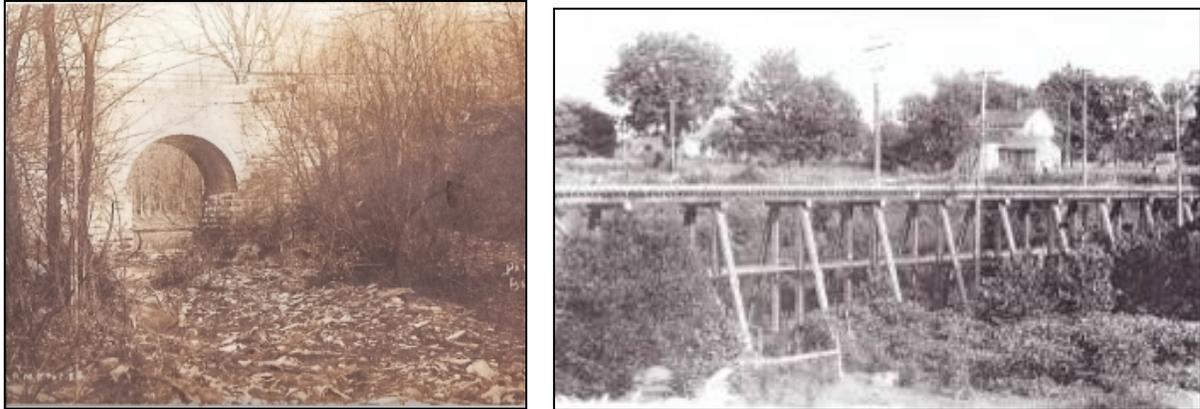


Figure 60: Bridge infrastructure crossing OWC in the 1900s: The Parmenter Bridge (left), and the Lake Shore Electric trestle bridge (right). (Berlin Heights Historical Society)

Historic infrastructure such as the Parmenter Bridge (Berlin Rd) and the Lake Shore Electric trestle bridge (circa 1902) once crossed OWC providing the transportation corridor to combat the terrain created by the Berea escarpment.

The community of Berlin Heights emerged from the resources available in the surrounding area. George Baillie took advantage of the sandstone found within the escarpment area and started the Baillie Stone Quarry. He later went on to build his residence in 1884 on Main Street, which still is considered the heart of the Village.

The Berlin Heights Feed Mill, was built in 1839 by Master Builder Joseph S. Lowry, which first was the Berlin Baptist Church. The church itself was moved in front of the Baptist Cemetery on Main Street and the building was later used as Belle Phillips's Horse stables and then the Feed Mill. Joseph S. Lowry also built the Congregational Church in 1848, which is still located on Main Street.

Through the Ohio Association of Historical Societies and Museums (OAHSM) the Historical Marker Program works with local communities to educate residents and visitors of significant features of Ohio's history. Old Woman Creek estuary (Marker #25-22) is the only site currently recognized in the OAHSM historical marker program.



Figure 61: Old Woman Creek Historical Marker #25-22

After an application submitted by the local community, this site became recognized in 2003 as a significant example of Ohio's estuarine systems.

Archeology. In the OWC watershed, data was recovered from two archaeological sites (Anderson and Jenkins) overlooking the estuary in 1976 and 1977 as part of a highway mitigation project before the construction of Ohio Route 2, which traverses the Reserve near the southern boundary (Figure 60). The results of these investigations were reported by Seeman and Bush (1979) and Shane (1981,1992). These sites document occupation by Paleo-Indian, Archaic, and Woodland peoples.

Artifacts found at the Anderson and Jenkins sites included: stemmed and unstemmed lanceolate projectiles (Late Paleo-Indian hunters); Brewerton side-notched projectile points, Genesee points, expanded-base drills, and polished slate atlatl weights (Late Archaic hunter/gatherers); a hearth and refuse pits, stemmed projectile points, thick-walled grit-tempered cord-marked pottery, and leaf-shaped chert bifaces (Early Woodland habitation); and bell-shaped refuse pit contained pottery similar to the Vase tool-impressed type of the Late Woodland Western Basin Tradition of northwestern Ohio and southeastern Michigan.

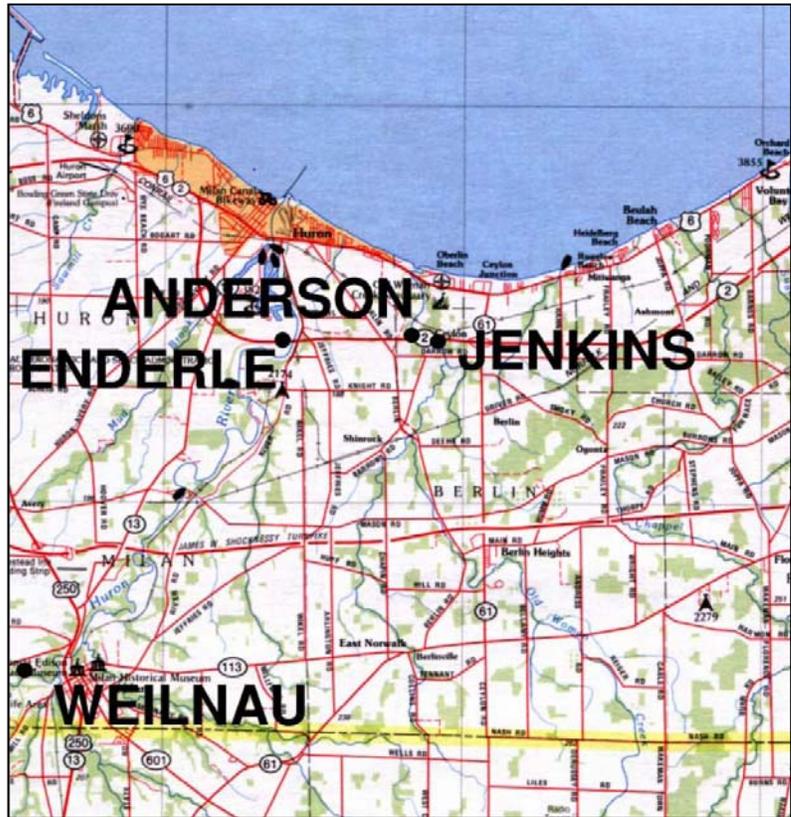


Figure 62: Archaeological sites in the vicinity of the OWC NERR. (Herdendorf, et al. 2004)

The most important component at the Anderson site was a 15th century Sandusky Tradition village. The most striking feature was a roughly circular enclosure (~64 m in diameter) that was bounded by a trench that appears to have served as a defensive structure for the village. Cultural debris was scattered throughout the enclosure trench: Grit-tempered pottery, various vessels, mixer tools, and projectile points were among artifacts retrieved. Three depressions and floors thought to be remainder of houses and refuse deposits. Both plant and animal remains were abundant in the refuse pits and middens. Floral remains included maize, hickory nut, butternut, acorns, and walnut, while faunal remains were deer, muskrat, rabbit, small rodents, birds, fish (especially bullheads, pike, and freshwater drum), and mollusks. Maize was the most common food source found in the pits.

20TH CENTURY LAND USE CHANGES

In conjunction with the Institute for Resource Information Systems of Cornell University, OWC NERR conducted a comparative study of land use patterns within the OWC watershed for the years 1937 and 1993 (Herdendorf 1997a). From the earliest (1937) and the most recent (1993) aerial photographs of the watershed, some 30 land use categories were discriminated and plotted for the entire 27-square mile watershed. Once plotted, the area of each of the hundreds of individual land use polygons was determined with a polar planimeter.

Table 17: Land use changes in OWC watershed 1937 to 1993

| Land Use Type | 1937 Percent (%) | 1993 Percent (%) | Percent Change (%) |
|----------------------------|---------------------|---------------------|-----------------------|
| Agriculture | | | |
| Cropland | 66.3 | 59.5 | -6.8 |
| Orchard & Vineyard | 5.1 | 2.6 | -2.5 |
| Pasture | <u>17.9</u> | <u>3.4</u> | <u>-14.5</u> |
| | 89.3 | 65.5 | -23.9 |
| Commercial & Manufacturing | <0.1 | 0.5 | +0.5 |
| Forest | 8.3 | 24.8 | +16.5 |
| Residential | 0.8 | 4.2 | +3.4 |
| Water | 1.2 | 2.1 | +0.9 |
| Transportation | <u>0.3</u> | <u>2.9</u> | <u>+2.6</u> |
| | | | +23.9 |
| Total | 100.0 | 100.0 | |

The most notable changes occurred in the agricultural and forest land categories. While active farm lands decreased by nearly 24% in the 56-year period, forested lands rose by over 16%. Presumably about 70% of the farm land that was vacated in the intervening years was permitted to return to woodland. Other modest gains occurred in the residential and transportation categories, approximately 3% each. From a total area standpoint, human land use of the watershed was less intense in the early 1990s than it was in the late 1930s. However, from an ecological viewpoint, the modern application of fertilizers, pesticides, and herbicides in the 1990s may overshadow this apparent environmental improvement.

Old Woman Creek watershed lies within the exurban region of the metropolitan urban centers of Toledo and Cleveland. Exurbia is described as a general mix of low-density urban and rural land uses found beyond the suburbs but within the “commuting zone” of larger urbanized areas. The exurban region often refers to the transitional area between high-density development and the rural landscape. Exurban development is created by a pattern of growth that spreads out or “sprawls” over time with little to no population growth. Ohio, which is one of the fastest urbanizing states in the nation, has followed this trend of urban growth increasing the rate of farmland loss and reducing the population density of metropolitan urban centers (Irwin and Reece, 2002). Although the watershed and surrounding areas

have seen modest population change, urban development in townships has increased and farmland acreage decreased suggesting this area is following the same development patterns seen in other parts of the state.

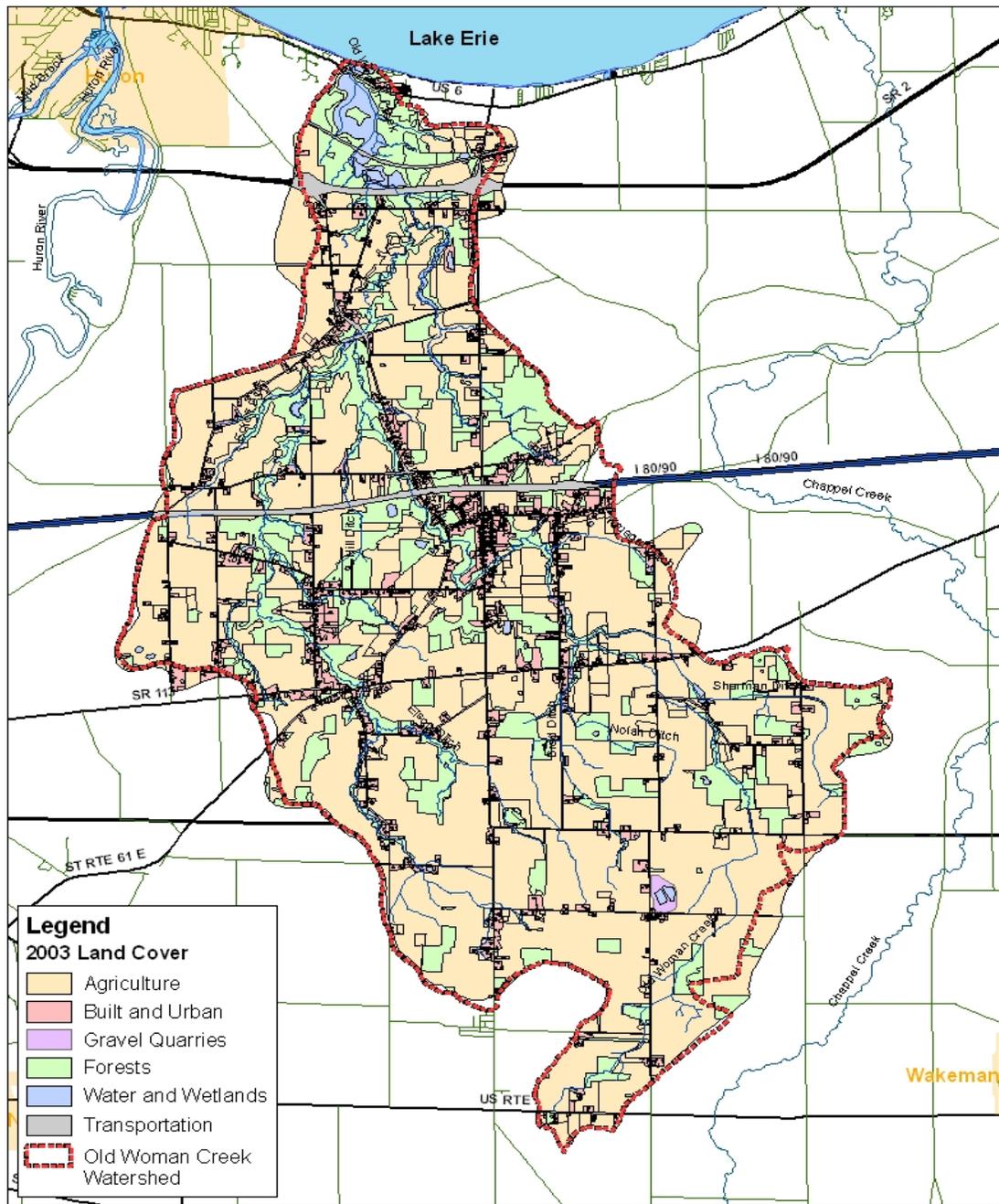


Figure 63: 2003 land use cover of Old Woman Creek watershed. (ODNR- Steve Barry)

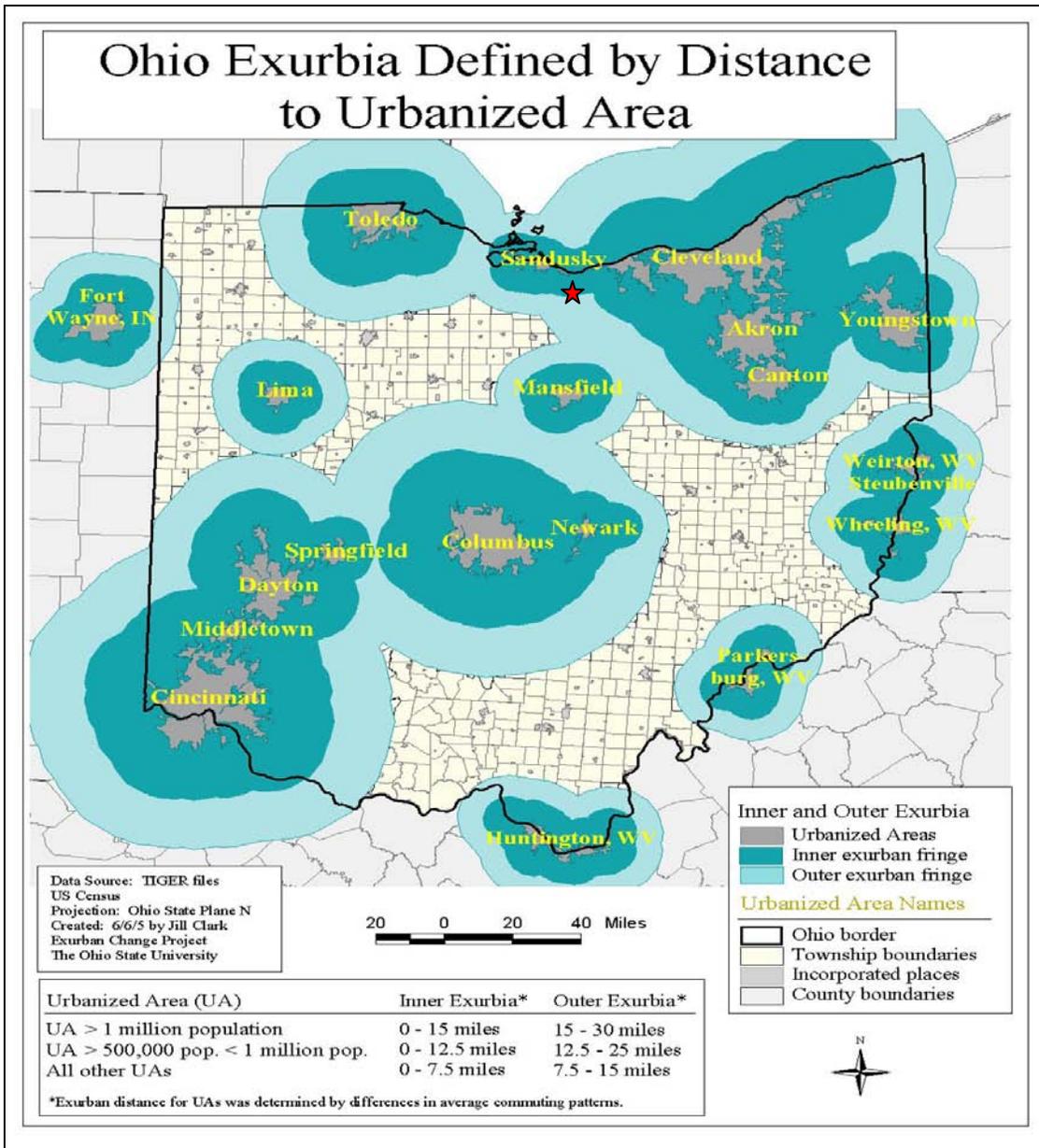


Figure 64: Exurban areas showing a connecting corridor between Toledo and Cleveland metropolitan areas which encompasses the OWC watershed (represented by the red star). (OSU)

The area immediately surrounding the estuary is undergoing rapid growth as planning for and construction of residential subdivisions and light industry moves forward. This development has been brought about, in large part, by recent improvements in the transportation infrastructure. With the completion of 4-lane State Route 2 in the late 1980s, with access ramps on both the east and west sides of the estuary, the lower OWC watershed is becoming an attractive residential and commercial site. A social science assessment of the OWC watershed conducted by NOAA noted that the watershed has a relatively high number of residents that commute to work.

Zoning. All communities (townships and villages) found within the OWC watershed boundary have some form of zoning regulations. The majority of OWC watershed (well over 75%) is zoned for agricultural/rural residential land use. Areas surrounding the watershed resemble similar zoning with the exception of urban zone classifications in the communities of Vermilion, Huron, and Milan. The flexibility afforded by Agricultural-Rural Residential zone designations may allow for more rapid conversion to urban setting. This may allow for increased development along arterial roads in the watershed from more established urban communities within the vicinity. Another form of sprawl may develop from the Village of Berlin Heights area should improvements to wastewater treatment become available without a defined community development plan focusing on congregating growth in and around the village. Currently, the lack of suitable lots needed for compliance with septic system regulations and low growth rates in Erie County has precluded the Berlin Heights area from previous growth predictions.

WATER AND WASTEWATER INFRASTRUCTURE

Drinking Water. In Huron and Erie Counties, residents rely on 75%-86% (respectively) on surface water for their drinking water source. In Erie County, water is provided through two agencies: The Erie County Department of Environmental Services (DOES) and Northern Ohio Rural Water. These agencies purchase water treated from plants located in City of Sandusky and Huron that is distributed through the watershed by their respective water lines. Both municipal treatment plants intake water from Lake Erie. In OWC, a development pattern (mainly new residential development) follows the installation of new water lines on arterial county and township roads. Most roads in the watershed already have or will have water lines. In Huron County, the closest surface water intake to OWC is in the City of Norwalk which is located within the Huron River watershed.

Wastewater Treatment. There are no centralized municipal wastewater treatment systems in the OWC watershed. It is presumed that many of the septic systems in the area may not function properly due to age, improper maintenance, or inadequate design or installation. Comments received by residents and the local health department suggested septic systems may be a water quality concern for OWC and nearby residents. Odors from catch basins within the Village of Berlin Heights as well as complaints filed with the Erie County Health



Figure 65: Berlin-Milan Elementary and Middle School package plant. (Hohman)

Department seem to support comments received from a watershed resident's referral to "blackwater icicles" found in the creek in winter on a survey. A recent study of septic systems in the Berlin Heights area conducted by the Erie County Health Department found that *E.coli* levels in OWC were above advisory levels in more than 50% of samples taken. Samples were taken 4 times at each site through the summer months of 2008. Only 7 of 22 sampled sites, (mostly located outside the village) did not register advisory levels of *E.coli*. Three sites located within Berlin Heights were higher than advisory limits for every sample. Moreover, on average these samples registered about 8 times higher than the advisory limit of 235 colony forming unites (CFU)/mL.

In addition to OWC water quality sampling in the Berlin Heights area, a survey was also conducted for information about residential and commercial sewage treatment systems. The results are as follows.

Table 18: Berlin Heights Area Residential and Commercial Sewage Treatment Systems Survey Results (2008).

| Berlin Heights Area Survey Results | | | | | | |
|------------------------------------|--------------|-------------------------|-----------|-----------|--------------------|----------------|
| Area | System Type | | Age | | Discharge Location | |
| | Septic tank* | Aeration | <20 years | >20 years | OWC/Storm sewer | Unknown outlet |
| Residential | 195 | 34 (17 non-operational) | 17 | 212 | 42 | 187 |
| Commercial | 16 | 4 (2 non-operational) | 1 | 19 | ?? | ?? |

**Residential- Septic tanks include leach field, filter beds or mound systems (non-aeration), Commercial – septic tanks include leach field type systems

Additional notes from survey:

- 6 commercial properties share 3 septic systems
- One commercial aeration system is considered oversized and has a NPDES permit

An additional site assessed as part of this project focused on the Oberlin Beach Community, which is not technically located within the watershed boundary but discharges to Lake Erie within one mile of the mouth of the creek. Due to exchange of waters between the lake and stream system the result of untreated waste discharge from this community may also have negative impacts to aquatic life and the recreational use of the estuary and associated shoreline. Samples taken from this location not only exceeded the advisory limit for human health and safety but also registered the highest among all samples taken in and near the OWC system. Samples reported confirmed *E.coli* ranging 2,420-15,530 CFU/100mL.

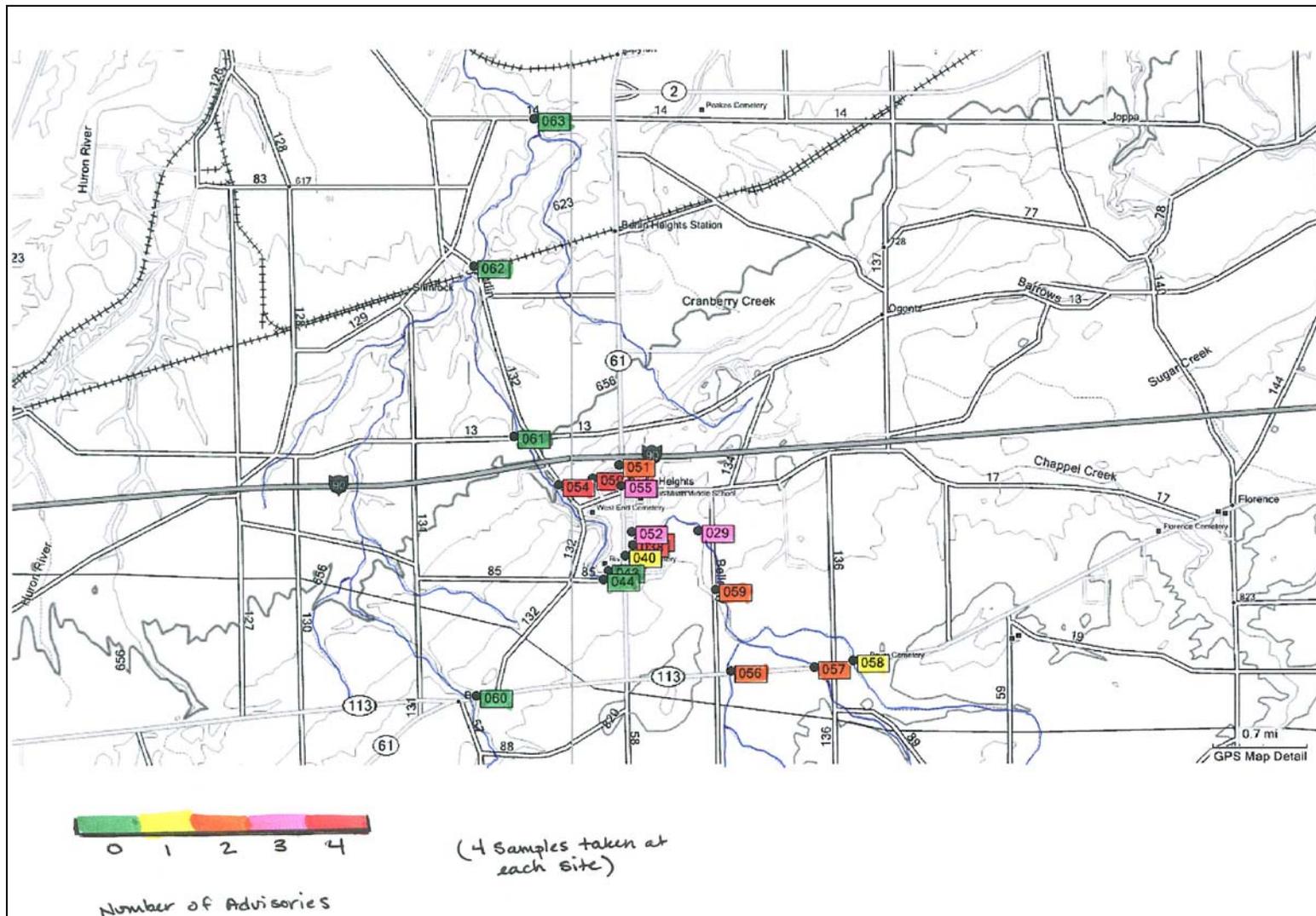


Figure 66: Results of *E. Coli* sampling of the Berlin Heights area in summer of 2008 showing advisory frequency at each site sampled.

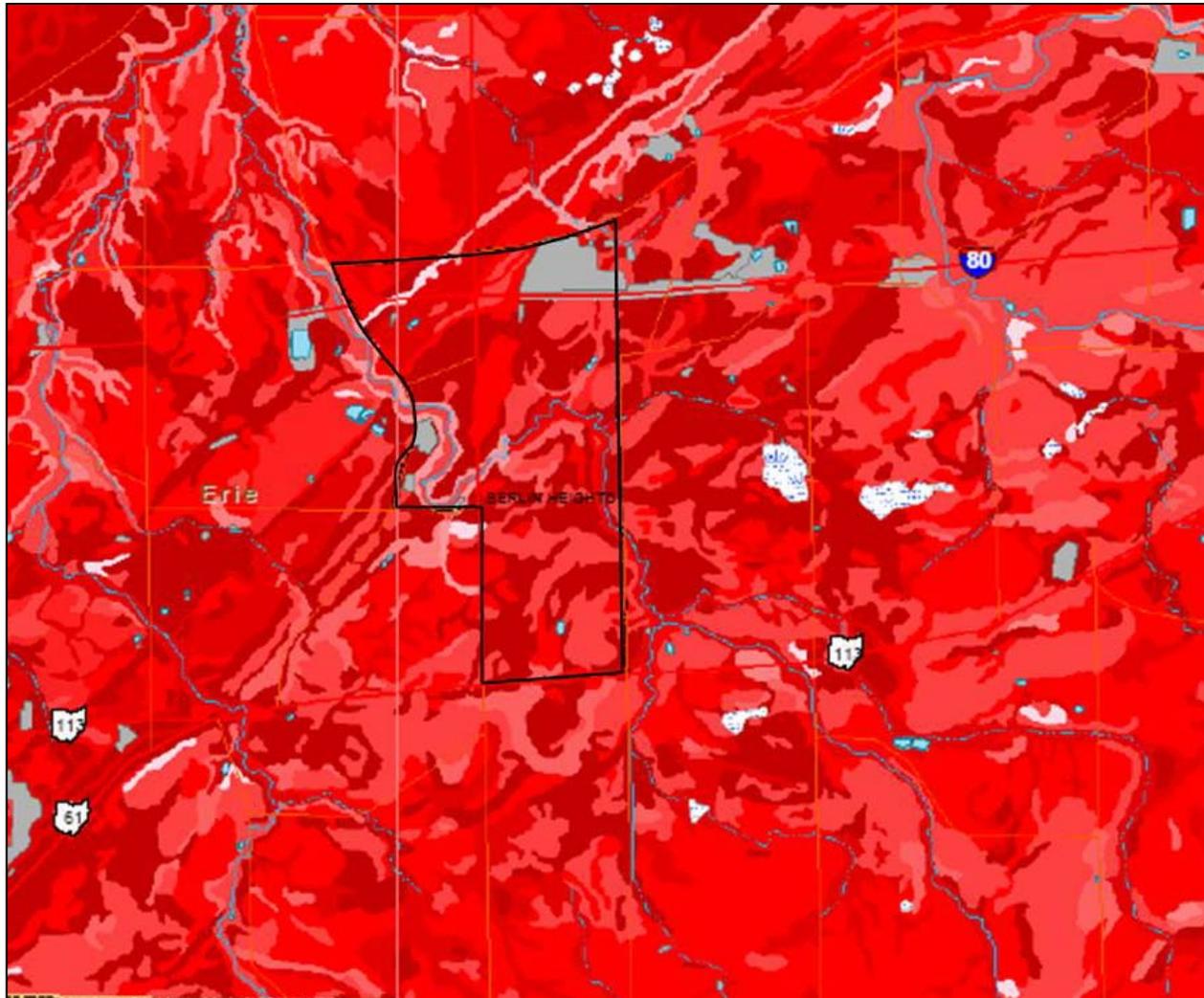


Figure 66: Soil filtration in the Berlin Heights area

Hazardous Materials. As a precaution against catastrophic oil spill and other hazardous material releases, an investigation of the potential for such accidents was undertaken in the OWC watershed (Wright et. al. 1991). An inventory of potential sources and pathways for spills within the watershed yielded useful land use data. For example, two primary types of spill hazards exist within the watershed: (1) those associated with transportation corridors and (2) those at fixed sites. These corridors or stationary sites either convey or hold hazardous materials, that if spilled within the watershed would ultimately enter the estuary, potentially causing severe environmental damage. Transported hazardous materials include: (1) petroleum and associated products, (2) toxic chemicals, (3) radioactive chemicals, and (4) bulk materials (e.g. ice control salts); whereas fixed sites hazardous materials consist of: (1) petroleum and associated products, (2) pesticides and herbicides, (3) liquid fertilizers, (3) industrial and commercial chemicals, (4) bacterial and viral chemicals, and (5) domestic chemicals.

Table 19: Transportation corridors and fixed facilities in OWC watershed

| | |
|--|--------------|
| <u>HIGHWAY & RAILROAD</u> | <u>MILES</u> |
| 4-lane highways (Ohio Turnpike; Ohio Rt. 2) | 9 |
| 2-lane highways (primary roads) | 21 |
| 2-lane highways (secondary roads) | 82 |
| railroad tracks | 8 |
| | <u>NO.</u> |
| 4-lane x 2-lane intersections | 2 |
| 2-lane x 2-lane intersections (primary) | 63 |
| 4-lane x 2-lane intersections (secondary) | 73 |
| railroad x highway intersections | 7 |
| bridges & overpasses | 8 |
| <u>PIPELINES AND TRANSMISSION LINES</u> | <u>MILES</u> |
| pipelines (petroleum & associated products) | 9 |
| pipelines (natural gas) | 14 |
| Transmission lines (high voltage) | 27 |
| <u>BUILDINGS</u> | <u>NO.</u> |
| houses (total in 1991) | 1,646 |
| houses (new between 1979 & 1991) | 284 |
| barns, greenhouses, & other outbuildings | 452 |
| commercial buildings | 58 |
| public & community buildings | 14 |
| industrial buildings | 9 |
| storage facilities (oil, natural gas, & chemicals) | 11 |

In addition to potential for spills of hazardous materials within the watershed, OWC estuary is also vulnerable to spill which may occur in the adjacent portions of Lake Erie. Short term oscillations in Lake Erie water level, (e.g. seiches and wind tides induced by certain wind or barometric conditions) periodically cause lake water to enter the estuary from the open lake. Such oscillations between peaks have periods of generally 12 to 14 hours. Therefore, if a spill was to occur in the nearshore waters

of the lake, response actions would need to be taken to protect the estuary from lake water, as well as the lake beaches.

PROTECTED PUBLIC LANDS

Old Woman Creek Reserve. Old Woman Creek National Estuarine Research Reserve is part of a national network of coastal reserves established as living laboratories for long-term scientific research and estuarine education. The Reserve was designated in 1980 and is managed as a cooperative partnership between the



Figure 67: View of Old Woman Creek estuary in fall. (Wright)

Ohio Department of Natural Resources (ODNR) and the National Oceanic and Atmospheric Administration (NOAA). Old Woman Creek is also dedicated as an Ohio State Nature Preserve. As a transition zone between land and water, the site contains a variety of habitats including marshes and swamps, upland forests, open water, tributary streams, barrier beach and near shore Lake Erie. The Reserve supports a diverse and important assemblage of native plants and animals representative of freshwater estuaries.

Edison Woods Preserve. The 1,300 acre preserve, once slated to become the site of a nuclear power plant, was conserved as an Erie County Metropark in 2001. Today it's a significant ecological area and Audubon Important Bird Area with headwaters to a tributary of OWC, and about 550 acres of wetland habitats and 300 acres of restored native grasslands. Sandstone cliffs, an escarpment of the Appalachian Plateau, protrude from the hardwood forests and wet meadows. Over 460 species of plants have been found in the preserve; spring wildflowers and several varieties of ferns grow in abundance. The preserve is home to several salamander species and an extensive variety of birds—occasionally a bald eagle may be seen soaring overhead. Opportunities for bird watching are outstanding, especially during spring migration; over 110 species have been seen on site.

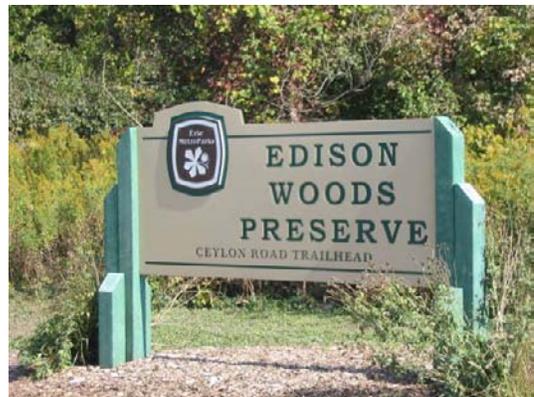


Figure 68: Entrance to Edison Wood Preserve (Elmer)



Figure 69: West branch of Old Woman Creek flowing through Hoffman Woods Preserve (Hohman)

Hoffman Forest Reserve. This 40 acre Reserve was made possible by a 20 year lease from H. Lowell Hoffman, M.D. to Erie MetroParks signed in 1995. Hoffman Forest Reserve features the intersection of two small intermittent branches of OWC. The reserve also consists of three main ecological communities; the creek bottom and surrounding valley; a large section of meadow/old field community; and a mature forest. The creek bottom and surrounding valley area includes a dense mixed forest, which surrounds the creeks and covers the valley slopes. This varied forest includes paw-paw, spicebush and several other shrub species.

Berlin Community Park. The Berlin Community Park is a 32 acre community park located behind the Berlin-Milan Middle School in the Village of Berlin Heights. This park boasts a playground area, tennis and basketball court, ball fields, shelter and wooded area with walk paths. The property is currently own by the Berlin Milan Board of Education and is the only one of its type in the OWC watershed.



Figure 70: Berlin Community Park shelter (Hohman)



Figure 71: Canoeing the estuary. (Hohman)

Recreational Significance. Public recreation opportunities found within the watershed include designated natural and park areas: OWC NERR, Edison Woods Preserve, Hoffman Forest Reserve, Berlin Heights Community Park. Collectively these areas offer hiking, horseback riding, and crosscountry skiing trails, canoeing, birdwatching, geocaching, wildlife viewing, play areas, and shelters. On privately owned land, recreation opportunities also include hunting, fishing, and recreation vehicle trails.

DEMOGRAPHICS

POLITICAL GEOGRAPHY AND DEMOGRAPHICS

Population and related demographics data is not accurately tracked on a watershed basis. To best estimate the population of the watershed, each township's population was considered to have an even distribution. The percentage of the land in the watershed within the township was used as a means of extrapolating a best estimate for the watershed population. All figures are based on this method of reasoning.

The OWC watershed encompasses land in two counties (by percentage of total watershed area).

1. Erie (79.3%)
2. Huron (20.7%)

Table 20. OWC Watershed population by county, municipality, and township (estimated).

| Erie County | Population | % land within OWC boundary | Huron County | Population | % land within OWC boundary |
|-------------------------|--------------|----------------------------|--------------------------------------|--------------|----------------------------|
| Berlin Twp. | 3,017 | 74.73 | Townsend Twp. | 1567 | 20.6 |
| Huron Twp. | 7,958 | 0.77 | Wakeman Twp | 951 | 0.1 |
| Florence Twp. | 2,500 | 2.38 | Total (Huron/OWC) | 322 | |
| Milan Twp | 3,686 | 1.43 | Est. total pop. OWC Watershed | 3,433 | |
| Berlin Heights | 685 | 100 | | | |
| Total (Erie/OWC) | 3,111 | | | | |

Table 21. Population data for the watershed counties from 1900-2004.

| County | 1900 | 1910 | 1920 | 1930 | 1940 | 1950 |
|--------|--------|--------|--------|--------|--------|------------|
| Erie | 37,650 | 38,327 | 39,879 | 42,133 | 43,201 | 52,565 |
| Huron | 32,330 | 34,206 | 32,424 | 33,700 | 34,800 | 39,353 |
| | | | | | | |
| | 1960 | 1970 | 1980 | 1990 | 2000 | 2006(est.) |
| Erie | 68,000 | 75,909 | 79,655 | 76,779 | 79,551 | 78,116 |
| Huron | 47,326 | 49,587 | 54,608 | 56,240 | 59,487 | 60,313 |

Table 22. Percent of population by Household Income for Erie and Huron Counties

| Household Income | Erie | Huron |
|------------------------|----------|----------|
| Total Households | 100% | 100% |
| Less than \$10,000 | 6.8% | 6.8% |
| \$10,000 to \$19,999 | 12.6% | 12.7% |
| \$20,000 to \$29,999 | 15.1% | 15.0% |
| \$30,000 to \$39,999 | 12.2% | 14.7% |
| \$40,000 to \$49,999 | 11.1% | 12.6% |
| \$50,000 to \$59,999 | 10.2% | 11.8% |
| \$60,000 to \$74,999 | 12.1% | 12.2% |
| \$75,000 to \$99,000 | 10.9% | 8.6% |
| \$100,000 to \$149,999 | 6.3% | 4.4% |
| \$150,000 to \$200,000 | 1.3% | 0.4% |
| \$200,000 or more | 1.5% | 0.9% |
| Median income | \$42,746 | \$40,558 |

****Unemployment Rate (2006): Erie- 5.9%, Huron – 7.4%**

Table 23. Percent of population by Education for Erie and Huron Counties

| Educational attainment (Persons 25 yrs and over) | Erie | Huron |
|---|-------|-------|
| No high school diploma | 16% | 19.4% |
| High school graduate | 41% | 48.8% |
| Some college, no degree | 20.5% | 16.7% |
| Associate degree | 5.8% | 4.7% |
| Bachelor's degree | 11% | 7.6% |
| Master's degree or higher | 5.6% | 3.3% |

Table 24. Political units and other entities within OWC Watershed

| County | Township | Locality | School District* | Other Planning Organizations |
|--------|----------|----------------|---------------------------------|------------------------------------|
| Erie | | | | Erie Regional Planning Commission |
| | | Berlin Heights | Berlin-Milan School District | |
| | Berlin | | Berlin-Milan School District | |
| | Huron | | Huron City Schools | |
| | Florence | | Western Reserve School District | |
| Huron | | | | Huron Regional Planning Commission |
| | Townsend | | Western Reserve School District | |

*each school district is listed at least once. Multiple districts may overlap within a given township, in which case the predominant district serving the watershed was listed.

Table 25. Agricultural Statistics, Erie and Huron Counties

| | Erie | | | Huron | | |
|------------------------------|-------------|----------------------|----------|-------------|-------------|----------|
| | 1997 | 2002 | % Change | 1997 | 2002 | % Change |
| Number of Farms | 431 | 392 | - 9% | 876 | 865 | - 1% |
| Land in Farms | 90,676ac | 94,681ac | 4% | 236,971 | 228,346 | - 4% |
| Average Farm Size | 210ac | 242ac | 3% | 271ac | 264ac | - 3% |
| Avg. Production/Farm | \$81,680 | \$83,180 | 2% | \$89,129 | \$76,759 | - 14% |
| Government Payments | \$1,146,000 | \$1,090,000 | - 5% | \$3,405,000 | \$2,981,000 | -14% |
| Gov't. Payments/Farm | \$5,404 | \$6,122 | 13% | \$6,494 | \$7,584 | 17% |
| Farm Land In Cropland | | 75,56ac ⁵ | | | 177,039ac | |

Population Trends (1986 Projection). Holly (1986) performed a demographic and economic analysis of the region surrounding OWC watershed and concluded that eastern Erie County lies in the path of the population expansion resulting from increased recreational and retirement use of the Lake Erie coast and the general dispersal of population away from central cities, such as Cleveland and Lorain. The forecasts made by Holly (1986) indicated steady increases in population in the townships and cities contiguous to and near the watershed, with a 12,000-person increase along the coastal area from Huron to Vermilion for the 25 years from 1980 to 2005. Rural, agricultural areas away from the coast, in the upper reaches of the watershed, were predicted to increase steadily, but more slowly than rural, non-farm areas. In both the coastal area and the upper watershed, the population increases were predicted to result in a steady conversion of agricultural and vacant land to residential use, with increases in water use, sewage generation, and local traffic. The completion of the Ohio Route 2 Bypass linking the cities east of Vermilion to the cities west of Huron (1989) was expected to increase accessibility to the OWC watershed, making it more desirable for residential development.

Forecasting population trends is a risky venture. The model developed by Holly (1986) forecasted a population increase of 22.3% (4,479 individuals) between 1980 and 1990 for the coastal area from Huron to Vermilion and a population increase for the upper watersheds from Milan to Florence of 7.4% (603 individuals). In actuality, the population in both sectors declined in the 10-year period between 1980 and 1990: -3.2% (-614 individuals) for the coastal area and -2.3% (-179 individuals) for the upper watersheds based on Census data. Population estimates for 1995, generated by the Ohio Department of Development, show some recovery in both sectors, but far below Holly's projections. An explanation may be that the rapid increases of the 1960s and 1970s reached a temporary saturation point in the 1980s as available infrastructure resources were being taxed to their limit and most of the prime development land had been secured for residential conversion. The opening of the Ohio Route 2 Bypass at the end of the decade, improvements in

water/sewage technology for remote locations, and economic prosperity appear to have stimulated a new round of development in the 1990s. Despite the increase in some infrastructure such as the addition of waterlines paralleling most arterial roads in the counties, the lack of a centralized waste water treatment combined with the rising cost of home sewage treatment systems has prevented the fast moving exurban development pattern within the watershed. This could change when Berlin Heights provides adequate waste water treatment options to allow growth.

Socioeconomic Characterization. In 2005, NOAA Coastal Services Center completed a community characterization study of the watershed and surrounding communities that provided the OWC NERR with essential social and demographic information for future planning efforts. Although this information was developed for use by the OWC NERR, it provides many insights about the community structure that are essential to watershed planning.

In summary, the report found that the watershed is comprised of a relatively low population density with a northern to southern trend from more affluent, highly educated, and powerful residents with higher ratios of children along the Lake to elderly, and lower median income levels further inland. Most areas surrounding the watershed had single-parent households above the state average; however, the OWC watershed was quite low in comparison. The study reconfirmed the idea that the watershed lies within a “commuter shed” of larger communities. A large majority of watershed residents commute 15 to 45 minutes to work each day. The study also describes the watershed and region in “flux”. The watershed is comprised as an area of strong communities and families, sense of place, and rural/small town character. The surrounding communities on the other hand have higher concentrations of poverty and population density. The report also noted that the area may be at risk of encroachment due to changing economic demographics. One example is the sale of farms as older owners are no longer able to manage them, and their children may not want to pursue this way of life. As a result, agricultural land sales give rise to new residential and commercial development.

Recommendations related to watershed planning from this study include using local people with local strategies and their internal networks to address natural resource management issues. This recommendation was in part the impetus for local non-profit organizations and agencies to undertake a watershed planning effort. Outreach and communication skills will need to be diverse to serve the many “communities” of the watershed and surrounding areas. Watershed stewardship education directed toward students may be most effective in the upper reaches of the watershed where ratios of children to elderly are high.

WATERSHED STEWARDSHIP

FARM BILL CONSERVATION PROGRAMS

The NRCS, FSA, and SWCD offices in Erie and Huron Counties have provided assistance and education to local agricultural producers to promote conservation practices as part of normal agricultural operations. Of the many Farm Bill programs that assist local farmers to address resource concerns, CREP, CRP, EQIP, and CSP are the most widely used programs offered.

Table 26. Farm Bill Conservation Programs OWC

| Practice | Acreage | Program |
|-------------------------------------|--------------|-------------|
| Crop Rotation | 878.3 | EQIP |
| Filter Strip | 3.2 | CRP |
| Filter Strip | 73 | CREP |
| Filter Strip | 7.7 | EQIP |
| Riparian Buffer | 3.8 | CREP |
| Nutrient Management (Crop) | 208.9 | EQIP |
| Nutrient Management (manure) | 669.4 | EQIP |
| Pest Management | 878.3 | EQIP |
| Waterways | 16 | CRP |
| Wetland Restoration | 2.4 | CREP |
| Wildlife Buffer | 43.2 | CRP |
| Wildlife Habitat (Grasses) | 89.2 | CRP |
| Windbreaks | 26.6 | CREP |

All contracted program acreage, with exception to 85.5 acres of EQIP, is located in Erie County. Average year for contract agreement expiration is 2012 for CREP and 2009-2018 for CRP.

The Conservation Stewardship Program (formerly the Conservation Security Program) is a program that provides incentives for addressing resource concerns and continuing agricultural conservation practices. In the Erie county portion of OWC, approximately 1,631.7 acres are currently under contract. Of these contracts 843.5 acres of contracts are set to expire in 2009 while 788.2 acres will expire in 2014. The Huron County portion of the watershed currently has no CSP contracts. CSP “sign-up” once occurred through targeting individual 8-digit watershed for a limited sign-up period. Beginning in 2009, CSP sign-up will be available to all of Ohio.



Figure 72: No-Till agricultural conservation practice. (ESWCD)

EDUCATION

The FCT partners have been devoted to providing education and increasing awareness of water resource issues to residents, professionals and decision-makers, locally and within the Lake Erie watershed. Many partners provide watershed related education consistent with their own stewardship objectives. Classroom activities, tours, demonstrations, outdoor workshops, and activity boxes are just a few of the educational opportunities provided by FCT partners such as: DOES, ESWCD, OWC NERR, EMP, Ohio CTP, and BGSU Firelands. Each partner provides different types of environmental stewardship, citizen responsibility, and ecology based programs. Below is a list of selected programs related to water quality and watersheds that have been provided to OWC and FCT area.

Table 27. Locally Provided Educational Water Quality/Watershed Programs and Tools available in OWC

| Program Title/Tool | Type | Lesson | Audience | Agency(s) |
|--|-------------------------------|------------------------------------|-----------------------------|----------------------------------|
| Healthy Water, Healthy People | Curriculum and activity guide | Water quality | Students/Teachers Family | ESWCD |
| Project Wet | Curriculum and activity guide | Watershed awareness | Student/Teachers Family | ESWCD, OWC NERR, EMP |
| Watershed Wonders | Informational education guide | Teacher education tool awareness | 4th -6th Grade Teachers | OWC NERR, ESWCD, EMP, DOES |
| Project Wild Aquatic | Curriculum and activity guide | Watershed ecology | Student/Teachers Family | OWC NERR, EMP |
| Enviroscape | Model/demonstration | Water pollution and BMPs | All | ESWCD, CTP |
| "Up The Creek" Watershed book | Citizens watershed guide | Watershed protection | Local Residents | OWC NERR |
| Watershed Jeopardy | Activity/game | Watershed awareness | All | DOES, ESWCD |
| Agricultural Producer Self Assessment Workshop | Workshop | Addressing resource concerns | Agricultural Producers | SRWC, ESWCD |
| Groundwater Model | Model/demonstration | Groundwater function and pollution | All | ESWCD |

Table 28. Locally Provided Educational Water Quality/Watershed Programs and Tools available in OWC – cont'd

| | | | | |
|--|---|--|---------------------------|-------------------------------------|
| Rain Garden Workshop | Workshop | Addressing stormwater pollution | All | ESWCD, EMP, OWC NERR Barnes Nursery |
| Rain Barrel Workshop | Workshop | Addressing stormwater pollution | All | ESWCD, EMP |
| Estuary Explorations | Various stewardship education programs for OWC NERR | Natural resource awareness | All | OWC NERR |
| Stream monitoring training | Workshop | Water quality monitoring procedures | Adult | ESWCD, OWC NERR, BGSU, ECOA, EMP |
| Landowner Program (Conservation Options) | Presentation | Conservation Easement awareness | Local Landowners | WRLC |
| Coastal Community Planning and Development | Workshop | Balanced growth | Local Decision Makers | CTP, OWC NERR |
| Managing Stormwater in Your Watershed | Workshop | Stormwater management | Local Decision Makers | CTP |
| Septic System Repair and Maintenance | Workshop | Awareness about system maintenance to potential homeowners | Real Estate Professionals | OWC NERR |
| FCT Council Lunch | Networking/outreach | Watershed related topics | FCT program partners | FCT partners |

DEMONSTRATION PROJECTS

Precision Farming and Streambank Stabilization Project. In 1996 and 1997, OWC NERR and local partners coordinated a demonstration project focused on habitat management and non-point pollution reduction within the watershed and exchanged information and technology developed from this project (Wright et al. 1997, 1998, 2000). The project highlighted precision farming and a bioengineering streambank stabilization project within the OWC watershed. The goal of the precision farming project was to protect surface and ground waters from pollution caused by excess application of agricultural chemicals. Local farmers who had participated in the project met at the Reserve to share results of their fall harvest yield monitoring efforts and to discuss the pros and cons of the computer software, satellite-based technology, and variable applicator equipment. The project successfully demonstrated that non-point pollution reduction through precision

farming generated economic benefits for farmers, the environment, and watershed community through improved water quality.

In addition to precision farming, streambank stabilization projects within the OWC watershed have been effective in improving water quality (Echelberger 1997). In conjunction with the ESWCD, OWC NERR has fostered a cooperative program with several watershed farmers to protect stream banks from erosion caused by tillage and livestock facilities that are in close proximity to the stream. By adding greenbelts on the stream banks, re-channeling streams as appropriate, cleaning out ditches, and providing fencing to keep livestock off the stream banks, the banks are healing themselves.

Rain Gardens. In 2007, presentations and how-to workshops on rain gardens began in Erie County as interest in the area grew regarding alternatives for mitigating and filtering stormwater on individual lots. After several presentations had been completed, the OWC NERR and Erie Metroparks suggested installing two demonstration gardens as part of a hands-on workshop for homeowners. The rain gardens were installed in 2008 at the DeWine Center of OWC NERR and Frost Center of Erie Metroparks Osborne Park. Both gardens were installed utilizing local partnerships, volunteers, and donations including assistance by Barnes Nursery, Erie County OSU Extension, Master Gardener's, local Girl Scout Troops, and other interested residents. The demonstration gardens have served as an excellent education and outreach tool for promoting watershed stewardship in the Firelands area.



Figure 73: OWC NERR DeWine Center rain garden. (VanZoest)

WATERSHED RESEARCH

The OWC NERR partners with federal, state, and local agencies and academic institutions to provide research opportunities including: technical assistance, facilities and equipment, potential funding sources, and a research fellowship program for graduate students. The information derived from the research program at OWC is useful in developing sound management practices for coastal wetlands of Lake Erie and the other Great Lakes. Over 200 publications based on research conducted at the Reserve, monitoring projects, BMP demonstrations, education and outreach projects have been completed by staff and partners. The OWC NERR also has a monitoring program to document both long-term changes and short-term variability in the estuary's water quality. This data is the basis for the NERR System-Wide

Monitoring Program (SWMP). SWMP provides a long-term data set of selected meteorological and water quality parameters collected at all NERR sites. Data is available for use in a real-time format. As an example, the metrological data is used to inform the integrated pest management practices of a local nursery. Nationally, this data set has been effective in addressing questions posed by both coastal decision makers and scientists on “no discharge zones” for boaters, impacts of urban runoff, and impacts of various agricultural practices. Additionally, the Reserve has conducted its own site-based water quality monitoring program that dates back to the early 1980s.

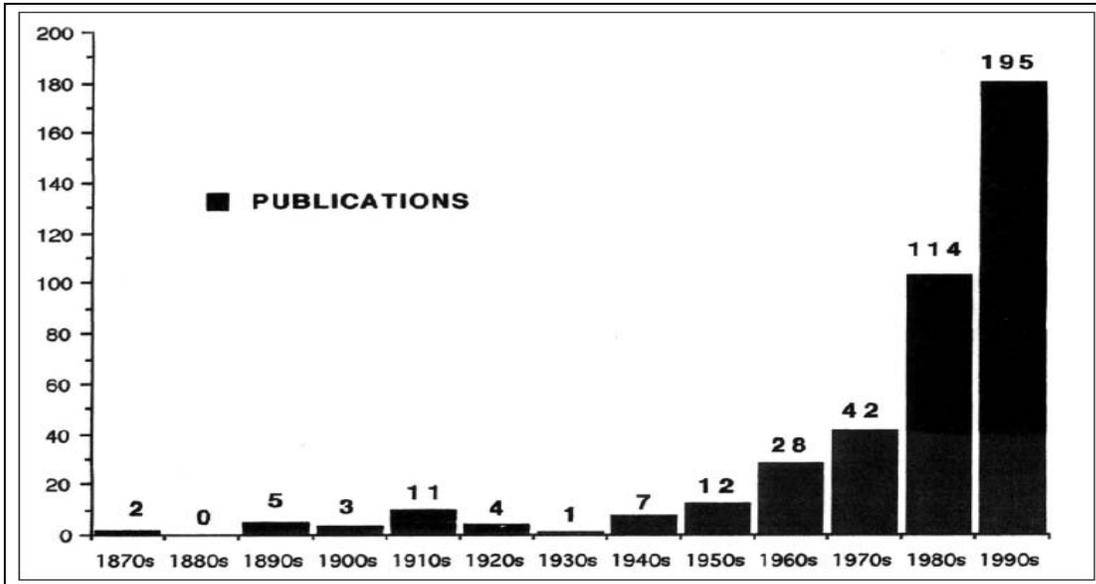


Figure 74: Peer-reviewed publications from research conducted in/around OWC NERR (Herdendorf et al. 2008).

TECHNICAL ASSISTANCE

Technical assistance for stormwater BMPs, balanced growth principles, and Phase II development and implementation has been provided by the FCT project partners and watershed coordinator in both Erie and Huron Counties. Land use planning assistance and stormwater BMP guidance have been provided by the Lake Erie Commission, the Ohio Coastal Training Program, and ODNR Division of Soil and Water Conservation. Locally, the ESWCD has had the opportunity to serve as a member of the Erie County Regional Planning Technical Advisory Committee to provide recommendations for sub-divisions and Planned Unit Development site designs. Partnering agencies of the FCT have also been called for assistance and recommendations for addressing resource concerns, stormwater retrofit options, and environmental enhancements by local agencies and private landowners.

PUBLIC PARTICIPATION

Focus Group Social Assessment. The data for this social assessment derived from key informant interviews and three focus groups with local residents connected to the OWC watershed or OWC NERR by either living in the watershed, working at OWC NERR or a related agency, or being members of the FOWC.

Common threads that emerged from the focus groups included that the area's landscape combined with its small town feel are strong factors that connect the community to the watershed and make the area desirable for newcomers. Unique ecosystems, climate, and proximity to larger cities are seen as factors that could generate development and growth in the area. All focus groups were in agreement that conversion of agriculture to urban land use has been the greatest change in the area and has directly changed other features of the community such as mindsets and community interaction. Many participants noted that the watershed is in risk of losing the enticements which could make it grow (small town feel, green space, nature). Largest community issues ranged from the shift of land use and change in economic development (beginning of stronger eco-tourism). It was feared that wastewater challenges associated with growth and development would reduce water quality and beloved green space.

The feeling of fear associated with land use change and sprawling development identifies the need to further study how land use planning is being conducted in the area. A large influx of "newcomers" in the area could offer an opportunity for greater participation in community-based watershed groups (If the main reasons for relocating include the natural landscape of the area and its close community interactions).

Watershed Survey. During the summer of 2007, a survey was sent to the watershed residents to gauge community views and attitudes about OWC and watershed stewardship. Over 200 surveys were completed, generating a response rate of 27.6%. Survey results displayed a generally high level of understanding of the relationship of land use and water quality. The opinions of watershed residents reflected the focus groups; most felt connected to the watershed for environmental and historical reasons as well as for drainage. There was a strong feeling that the watershed is in good condition with relatively few major issues affecting the quality of the stream. Of the issues listed by respondents, pollution, erosion, and water clarity are viewed to be the largest problems associated with the creek. There was a feeling that land use change is responsible for increased pollution in the watershed. Perceived responsibility for the restoration and protection of the watershed varied from the individual landowner to governments at all levels. Several residents indicated they would like to be more involved with the community decision-making process. Additional comments made by respondents referring to changes in the watershed pointed to perceived restrictions on stream access and recreational activities. Many associated protection of the estuary, with restrictions on fishing and hunting opportunities for the local community.

Because of the understanding of land use and water pollution, educational strategies for increasing stewardship in OWC should provide instruction on stewardship techniques within the watershed such as septic system maintenance, natural landscaping, etc. One limitation found within the responses suggested that several residents' expressed opinions were based on their perception of OWC NERR and not the entire watershed. It may be beneficial for the residents to understand the geographic extent of their watershed to develop a strong "watershed community". The strong feeling of importance and place OWC has in the community combined with negative views of perceived land use change reflect themes that emerged from focus groups. The variety of opinion relating to responsibility for the creek's management suggest that watershed planning will be most effective if it involves both government and watershed residents. Enhancing the recreational opportunities within the OWC may also increase the level of ownership among residents.



Figure 75: OWC WAP public meeting held at the Berlin Township Fire Hall in 2007. (Hohman)

Public Meetings. In 2007 and 2008, the FCT program offered four opportunities to educate and discuss the idea of a watershed plan for OWC. These meetings allowed residents and other stakeholders to learn about the various scientific reports characterizing qualities and impairments of the stream and discuss their personal opinions of changes they have witnessed in their community. Information gathered from these meetings were integrated into the development of the OWC WAP objectives matrix which served as a precursor for this plan.

VOLUNTERISM

The FCT relies heavily on volunteer support in implementing several objectives of the program. Success of watershed projects hinges on the engagement of the community and developing a sense of ownership for the resource. The FCT works to develop volunteer opportunities that enhance the connectivity of the volunteer to the resource and inspire citizen responsibility. Volunteers are utilized for all aspects of the program including: education and outreach, monitoring, stream clean-ups, watershed planning, and restoration projects. Opportunities



Figure 76: Soliciting volunteers at the Erie County Volunteer Day held at the Sandusky Mall. (Hohman)

offered through the program are geared to empower the volunteer by creating an experience that both motivates and teaches stewardship. Our volunteer list was developed by combining existing volunteer lists of the FCT partners and through general media advertisements about particular opportunities. The FCT program has also worked with the Volunteer Center of Erie County to market for stream monitoring volunteer opportunities on the Center’s website as well as referring interested volunteers for other aspects of the program.



Figure 77: Volunteer picking up litter from a roadside ditch during the Great American Clean-up event. (Hohman)

Stream clean-up & restoration events. Clean-up events provide short-term volunteering opportunities rather than the longer commitment of stream monitoring. Clean-up events have taken place for litter or larger debris. Restoration events include the removal of invasive species, planting of native species, and installation of BMPs such as rain gardens. These events are generally developed by an FCT partner acting as lead organizer and not by the FCT committees; however, networks developed

through the program are often used to build the volunteer base, develop advertisements, and share expensive supplies and equipment. Clean-up and restoration events in OWC have primarily been organized by the OWC NERR staff. These events have included stream, beach and roadside litter clean-ups, removal of invasive species, and planting of native species within the Reserve boundary.

Table 29. Clean-up and Restoration events completed in the OWC watershed in 2008.

| Event | Description | Result |
|--------------------------|--|----------------------------|
| Beach clean-up | 2.3 miles of beach as part of International Coastal Clean Up Week | 990 lbs litter collected |
| Roadside Clean-up | Two clean-up events on Rt 2 within the watershed (event was part of International Coastal Clean Up Week) | 500 lbs litter collected |
| Rain Garden Installation | Rain garden installed at OWC NERR Visitors Center | 1000 sq. ft garden planted |

Stream Monitoring. The Volunteer Stream monitoring group “Tribes Team” was formed in fall 2007 to begin chemical water quality sampling within the OWC and Pipe Creek watersheds. Through this program, 15 volunteers are currently monitoring over 20 sites on the two streams. Volunteers select sites they will be responsible to monitor each month for one sampling year (April-November). The FCT provides volunteers with a skill building experience in exchange for their time. Volunteers develop skills from monitoring protocol



Figure 79: Practicing tritration methods for determining dissolved oxygen levels in stream. (Hohman)

to analysis and presentation of data to the public. The goals of this program are to

provide credible data that may be used for watershed planning and

program evaluation as well as to provide a meaningful and educational experience to volunteers. In order to accomplish the goal of credible data, the monitoring committee has drafted an official study plan (Appendix XX) for the two streams and will be seeking approval through the Ohio EPA. Until this approval is attained, the data will be used exclusively for educational purposes.

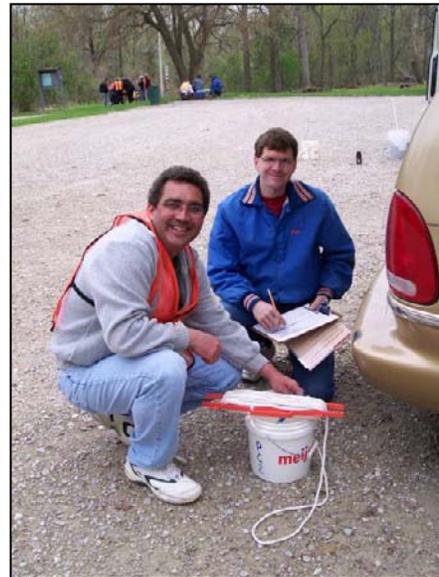


Figure 78: Volunteers happy to begin monitoring the stream after completing training. (Hohman)

Community Engagement through Local “Friends” Groups. Several volunteers have also supported the FCT program and watershed stewardship efforts within the FCT area through education and outreach. The FOWC and Friends of Pipe Creek Watershed have participated in several public events including the Earth Day Extravaganza, Harvest Happenings, The 4th of July Celebration, and the Berlin Heights Basket Festival. At these events, the Friends groups educate local residents on non-point source pollution and watershed stewardship. These groups have enhanced watershed efforts in the community and through face-to-face contact, have inspired residents to become engaged in the planning process. The Friends groups also serve as an outreach tool for the program through their grassroots approach to media (newspaper and newsletter articles), through public meeting preparation assistance, and through individual contact with residents and public officials on behalf of OWC and its watershed.

Chapter 5. Water Resource Quality

Water Quality Standards and Beneficial Use Designations

Water quality standards contain two distinct elements: designated uses; and numerical or narrative criteria designed to protect and measure attainment of the uses. (OAC 3745-1)

Beneficial use designations describe existing or potential uses of water bodies. They take into consideration the value of the water body for public use, protection and propagation of aquatic life, recreation, agricultural, industrial and other purposes. Ohio EPA assigns beneficial use designations to water bodies in the state. There may be multiple uses assigned to a single water body. Examples of beneficial use designations include: public water supply, primary contact recreation, and aquatic life uses (warmwater habitat, exceptional warmwater habitat, etc.) This section will cover only the use designations found within the OWC watershed, for additional information visit <http://www.epa.state.oh.us/dsw/wqs/index.html#Background>.

Table 30. Overview of Sub-category Use Designations in OWC

| Segment | Warmwater Habitat | Agricultural Water Supply | Industrial Water Supply | Primary Contact Recreation | State Resource Water |
|---|-------------------|---------------------------|-------------------------|----------------------------|----------------------|
| OWC Estuary (Within Reserve Boundary) | ✓ | | | ✓ | ✓ |
| All Other Stream Segments | ✓ | ✓ | ✓ | ✓ | |

AQUATIC HABITAT USE DESIGNATIONS IN OHIO

Water quality standards consist of designated uses and the chemical, physical, and biological criteria designed to represent measurable properties of the environment that are consistent with the goals specified by each use. Prior to 1978, Ohio's water quality standards specified only one general aquatic life use designation for all waters of the state. In 1978, the standards were revised in an attempt to recognize the variability inherent in natural aquatic ecosystems by having a tiered classification scheme for different aquatic life uses. Although the classifications were based upon ecological attributes, the criteria associated with them at the time were entirely chemical and physical. This changed by 1980, when the early biological criteria were developed. These biocriteria, derived from the tiered use designations, were in turn the forerunners of the current system of numeric biocriteria.

The tiered system of use designations provides for different levels of protection and reflects the choices implicit in reconciling the "ideal" (represented by least impacted reference conditions) with the "reality" of the ongoing effects from two centuries of intensive human use of the state's land and water resources.

The aquatic life use designations are assigned to individual waterbody segments based upon the potential to support that use according to narrative and numerical criteria. Observing actual attainment of the criteria in order to designate a particular use is not necessary; if this were the case, there would be little incentive to improve degraded aquatic systems.

The Warmwater Habitat (WWH) use designation is applicable to most of the state's rivers and streams. The Exceptional Warmwater Habitat (EWH) use designation is used for waters with unique and unusual assemblages of aquatic life (e.g., waters with the potential for significant populations of endangered species, unusually good chemical quality, above-average abundance of sensitive species, above-average populations of top carnivores). The Modified Warmwater Habitat (MWH) use designation applies to extensively modified habitats that are capable of supporting the semblance of a warmwater biological community, but fall short of attaining WWH because of functional and structural deficiencies due primarily to altered habitats. The lowest degree of biological integrity, reflecting poor and very poor communities, is Limited Resource Water (LRW).

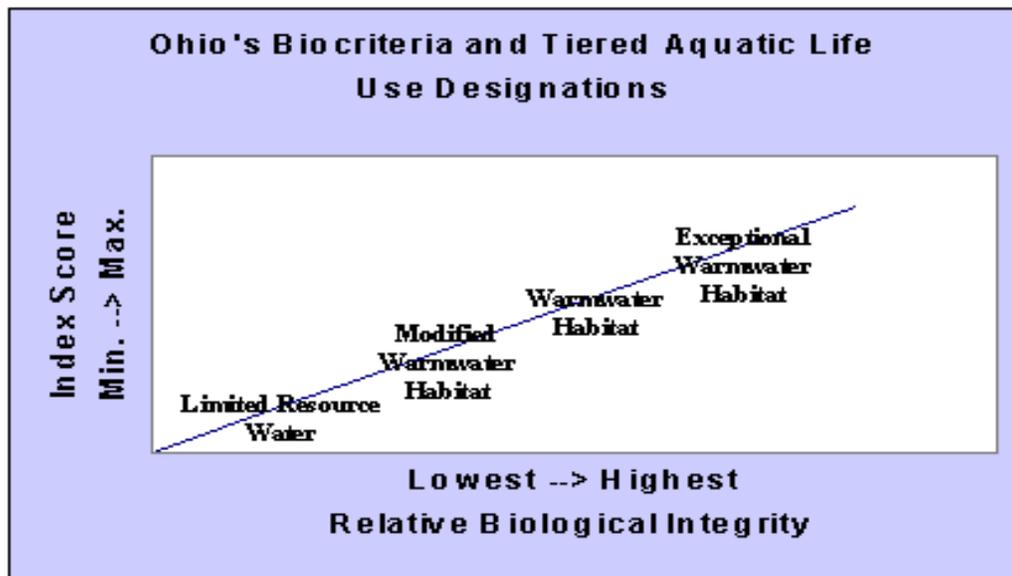


Figure 80: Ohio's Biocriteria Aquatic Life Use Designations defined by the Ohio EPA. (<http://www.epa.gov/waterscience/biocriteria/casestudies/aquaticlifeohio.html>)

Degrees of Use Attainment for Ohio Streams and Rivers: The OEPA has developed a standard set of terms to describe the degree to which biological use attainment is being met. These are as follows:

- A. **Fully Attaining** - All biological indices meet standards.
- B. **Partially Attaining** - One of two or two of three indices do not meet criteria but are not in the poor or very poor category.
- C. **Non-attaining** - None of the indices meet standards or one organism group indicates a severe toxic impact (poor or very poor category) even if the other organism groups indicate attainment.

USE DESIGNATIONS FOR OLD WOMAN CREEK

AQUATIC LIFE

Warmwater Habitat. Water bodies capable of supporting and maintaining a balanced, integrated and adaptive community of warmwater aquatic organisms. The typical assemblages of fish and invertebrates are present, similar to least impact reference condition. This is the baseline regulatory requirement in line with the Clean Water Act “fishable goal” expectations.

Biological Indices. The fish and macroinvertebrate data are used to calculate the following three indices, as described in the OEPA Guide and presented below:

- **Index of Biological Integrity (IBI)** - The index of biological integrity is a measure of fish species diversity and populations. The index is a number that reflects total native species composition, indicator species composition, pollutant intolerant and tolerant species composition, and fish condition. Combined, the higher the calculation, the healthier the aquatic ecosystem; conversely, the lower the index, the poorer the health of the aquatic ecosystem. The highest score is 60.
- **Modified Index of Well Being (MIwb)** - the modified index of well being factors out 13 pollutant tolerant species of fish and includes fish mass in the final analysis. Thus, if the IBI and the MIwb are examined together, an even clearer picture of the health of the biological community emerges. For example, if a high IBI is coupled with a low MIwb, it would tell us that while there is a variety of species and a good number of individuals of each species (high IBI) individual members of these species are smaller than what is expected. This might indicate that while fish are numerous, they are not maturing fully. In turn, this information could be useful in determining which pollution source is impacting the biological community. The highest value of the MIwb is 12. The MIwb is not applied to stream segments with drainage areas less than 20 square miles.

- **Invertebrate Community Index (ICI)** - the invertebrate community index is based on measurements of the macroinvertebrate communities living in a stream or river. It is particularly useful in evaluating stream health because: (1) there are a wide variety of macroinvertebrate taxa, which are known to be pollutant intolerant; and (2) there are a number of macroinvertebrate taxa, which are known to be pollutant tolerant. Like the IBI, the ICI scale is 0 - 60 with higher scores representing healthier macroinvertebrate communities.

Table 31. Ecoregional Biocriteria: Eastern Corn Belt Plains (ECBP) and Eastern-Ontario Lake Plain (EOLP) (Old Woman Creek and Chappel Creek Watersheds TMDL – OEPA 2005).

| Site type | IBI | | Mlwb | | ICI | |
|------------|------|------|------|------|------|------|
| | ECBP | EOLP | ECBP | EOLP | ECBP | EOLP |
| Headwaters | 40 | 40 | | | 36 | 34 |
| Wading | 40 | 38 | 8.3 | 7.9 | 36 | 34 |
| Boat | 42 | 48 | 8.3 | 9.6 | 36 | 34 |

Habitat Assessment.

Qualitative Habitat Evaluation Index (QHEI) The QHEI index is intended to provide a quantitative evaluation of the qualitative physical characteristics of a given stream reach. This index is similar to the biological indices, IBI and ICI and is measured at each site where IBI data is obtained (Ohio EPA 1989). Again, similar to IBI and ICI, QHEI is composed of six metrics which take into account variables such as bottom substrate, channel morphology, riparian cover, and other modifications to the stream stretch under investigation. A QHEI measurement can have a maximum score of 100. The following is a brief description of the metrics comprising Ohio EPA's QHEI as outlined by Ohio EPA (1989).

- **Substrate** - measures two components - substrate type and substrate quality; takes into account variables like parent material, embeddedness of cobble, gravel and boulders and silt cover. The maximum score is 20
- **Instream Cover** - measures instream cover type and amount. The maximum score is 20
- **Channel Morphology** - includes channel sinuosity, development, stability and channelization; indicates the quality of the stream channel in relation to creation and stability of the macrohabitat. The maximum score is 20
- **Riparian Zone and Bank Erosion** - measures floodplain quality, extent of bank erosion and the width of the riparian zone; serves as indication of the quality of the riparian buffer and floodplain vegetation. The maximum score is 10

- **Pool and Riffle Quality** - component measures include overall diversity of current velocities, pool depth and morphology and riffle-run depth, substrate and substrate quality; serves as indication of the quality of the pool and riffle habitats. The maximum score is a combined 20 (12 for pool, 8 for riffle)
- **Map Gradient** - calculation of elevation drop through sampling area; accounts for varying influence of gradient with respect to stream size. The maximum score is 10

WATER SUPPLY

Agricultural – these are waters suitable for irrigation and livestock watering without treatment.

Industrial - these are waters suitable for commercial and industrial uses, with or without treatment. Criteria for the support of the industrial water supply use designation will vary with the type of industry involved.

RECREATIONAL USE

The recreational season in Ohio is from May 1 to October 15. During this period, surface waters must meet numerical criteria which protect recreational uses.

Primary Contact - are waters suitable for full body contact recreation such as, but not limited to, swimming, canoeing and scuba diving with minimal threat to public health due to water quality.



Figure 81: Canoeing the estuary is one example of primary contact recreational use in OWC. (VanZonest)

STATE RESOURCE WATER

The water is among the very best within Ohio; supports very diverse aquatic life and/or endangered or threatened species.

Overview of Recorded Water Quality Impairments

The Ohio EPA report, *Biological and Water Quality Study of the Vermillion River, Old Woman Creek, Chappel Creek, Sugar Creek, and Selected Lake Erie Tributaries (2002)* concludes that impairments in the OWC watershed affect the aquatic life use designation and not the recreational or water supply use

designations of the creek. The integrated report (2004) and TMDL (2005) for OWC furthered described the impairments as follows:

- **Sediment/Siltation**
- **Nutrient Enrichment**
- **Habitat Alteration**

Causes listed for these impairments are listed include:

- **Non-irrigated crop production**
- **Pasture/Livestock**
- **Channelization**

TMDL Sediment Load Reduction – 2,876.6kg/d (1,050 tons/yr)

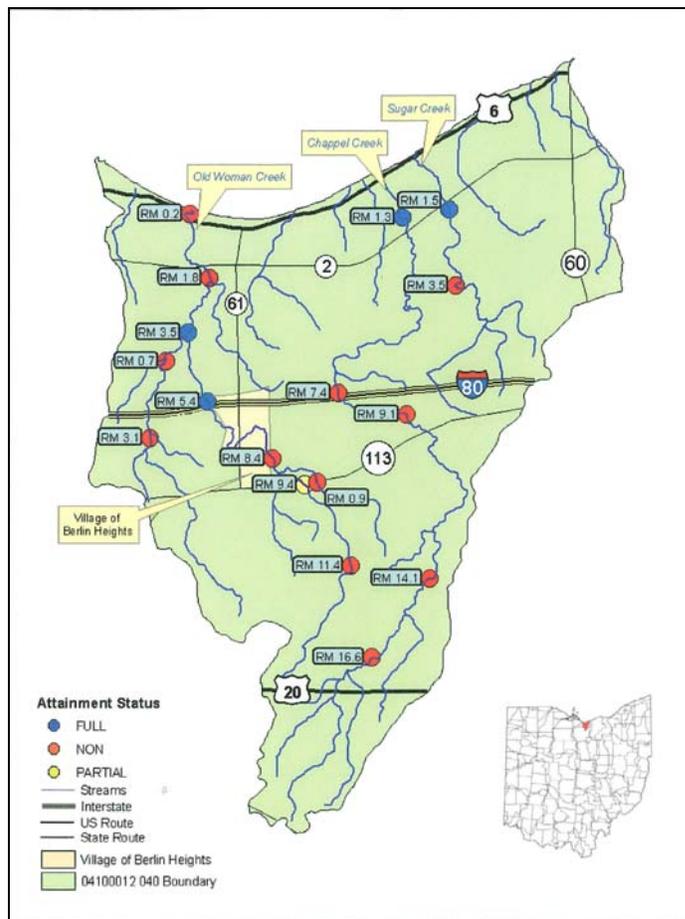


Figure 82: Ohio EPA TMDL study area and attainment status showing Old Woman Creek (OEPA, 2005)

Table 32. Ecoregion Location, Use Designation, and Aquatic Life Use Attainment of the OWC Watershed. (Old Woman Creek and Chappel Creek TMDL – OEPA 2005).

Main Branches of OWC (east and west)

| River Mile | Drainage Area | IBI | MIwb | ICI | QHEI | Attainment Status | Impairment |
|---------------------|---------------|------------------|--------------|------------------|------|-------------------------|-------------------------------|
| WWH –ECBP Ecoregion | | | | | | | |
| 11.4 | 2.4 | <u>24</u> * | NA | <u>P</u> * | | NON [^] | Flow Alteration |
| 9.4 | 3.4 | 36 ^{ns} | NA | F* | 41.0 | PARTIAL | Siltation/Habitat Alteration |
| WWH –EOLP Ecoregion | | | | | | | |
| 8.4 | 7.8 | 32* | NA | P* | 74.5 | NON | Organic/Nutrient Enrichment |
| 5.4 | 11.8 | 38 ^{ns} | NA | G | 66.0 | FULL | |
| 3.5 | 21.0 | 38 ^{ns} | NA | MG ^{ns} | 73.5 | FULL | |
| 1.8 | 29.0 | <u>24</u> * | NA | <u>16</u> * | | NON | Siltation/Nutrient Enrichment |
| 0.2 | 30.0 | <u>19</u> * | <u>5.4</u> * | <u>P</u> * | 36.5 | NON | Siltation/Nutrient Enrichment |

Tributary to OWC (RM 8.82)

| River Mile | Drainage Area | IBI | MIwb | ICI | QHEI | Attainment Status | Impairment |
|--|---------------|-----|------|-----|------|-------------------|------------------------------|
| Undesignated/Recommended WWH –ECBP Ecoregion | | | | | | | |
| 0.9 | 1.8 | | | VP* | | NON | Siltation/Habitat Alteration |

Tributary to OWC (RM 3.7)

| River Mile | Drainage Area | IBI | MIwb | ICI | QHEI | Attainment Status | Impairment |
|--|---------------|-------------|------|----------|------|-------------------------|-----------------|
| Undesignated/Recommended WWH –EOLP Ecoregion | | | | | | | |
| 4.9 | 4.5 | 28* | NA | F* | 67.5 | NON [^] | Flow Alteration |
| 5.4 | 7.9 | <u>26</u> * | NA | <u>P</u> | | NON [^] | Flow Alteration |

ICI categories – VP (very poor), P (poor), F (fair), G (good), MG (moderately good), G (good)

* -Indicates significant departure from applicable biocriteria (< 4 IBI or ICI units, or < 0.5 MIwb units). Underlined scores are in the poor or very poor range.

NS – Not Significant departure from biocriteria (< 4 IBI or ICI units, or < 0.5 MIwb units)

[^]NOTE: Flow alteration was not addressed in the TMDL under the assumption this “impairment” was a naturally caused event due to drought.

Old Woman Creek NERR Water Quality

Table XX: Water quality in the lower reach of Woman Creek at the N&W Railroad Bridge for four time periods.

| Parameter | 1981-1983 | 1995-1997 | 1998-2000 | 2006-2008 |
|---|------------------|------------------|------------------|------------------|
| Temperature (°C) | | | | |
| mean | 11.4 | 13.7 | 15.4 | 14.7 |
| range | -2.0-25.0 | 0.4-24.6 | 0.7-24.5 | 2.4-23.2 |
| Dissolved Oxygen (mg/l) | | | | |
| mean | 9.5 | 8.9 | 7.7 | 8.3 |
| range | 1.8-15.0 | 4.4-14.4 | 2.6-15.1 | 6.3-12.9 |
| Specific Conductivity (µmhos/cm) | | | | |
| mean | 706 | 613 | 636 | 687 |
| range | 389-1191 | 403-1117 | 317-1074 | 414-974 |
| Turbidity (NTU) | | | | |
| mean | 23.6 | 23.5 | 29.9 | 21.80 |
| range | 2.4-150 | 2.9-300 | 1.6-354 | 3.1-100 |
| Soluble Reactive Phosphorus (µg P/l) | | | | |
| mean | 31.4 | 28.9 | 41.5 | 22.98 |
| range | 1.5-129.9 | 1.4-103.8 | 0.0-468.2 | 2.2 – 58.5 |
| Nitrate (mgN/l) | | | | |
| mean | 1.918 | 2.652 | 3.168 | 2.60 |
| range | 0.012-7.578 | 0.0-6.354 | 0.008-15.153 | .0031-13.333 |
| Ammonia (mgN/l) | | | | |
| mean | 0.155 | 0.147 | 0.089 | .0477 |
| range | 0.001-1.472 | 0.008-.840 | 0.015-0.526 | 0.002-2.243 |

Chapter 6. Goals and Strategies

SEDIMENT POLLUTION

BACKGROUND

Old Woman Creek, like many watersheds in the Lake Erie basin, is negatively impacted by sediment loading primarily from agricultural land use. The highest sediment loading events in the OWC watershed occur during field preparation of spring planting and fall harvest where the highly erodible soil of the till plain region is temporarily disturbed (Woods, 1987). The southeastern portion of OWC watershed appears to be the most susceptible to soil

erosion, sediment yield, and resultant loadings (Herdendorf, et al. 2004). This region is characterized by Bennington-Cardington-Condit association soils, which have the highest erodibility potential of the soils in the watershed. This region also lies at the transition from till plain to escarpment where the slopes are steepest.



Figure 84: Streambank erosion and in-stream sedimentation visible in upper reaches of watershed. (Hohman)



Figure 83: Sediment laden water visible despite of recent storm event. (Hohman)

Prehistorically, 8,000 years ago, OWC stream gradients were higher (and thus velocities) developing a bed substrate of course to fine sands and silt. With the rising of Lake Erie's water level, stream gradients were reduced, changing the dominant bed substrate to finer materials within the estuary. In the last 100 years, agricultural land use has accelerated the deposition of silts and clays to a rate estimated to be ten times higher (2.3 ton per acre per year in the Till Plains) than the average loading rate of 8,000 years ago. (Buchanan, 1982; Evans and Seamons, 1997). This has resulted in unfavorable conditions for

native fish species requiring clear water and sand or gavel substrate for spawning, and, thus, a fish community dominated by more tolerant species.

The erosion process and sediment transport in OWC is considered highly episodic, governed by the intensity of rainfall (storm event) and the characteristics of the soil itself. For example, it was recorded that 26% of the average annual suspended sediment load occurred in just one sampling day in spring when fields have the highest rate of disturbance (Evans and Seamon 1997). Land use activities previously described as being directly correlated to sediment loading (Woods, 1987) was later confirmed by Matisoff (1999) who concluded that conventional tillage results in higher sediment loading than no-till practices. Although conservation programs have increased in the OWC watershed over the past 20 years, sediment remains the most serious water quality issue in OWC.

Suspected Causes of Sediment Loading

- Agricultural run-off (field erosion)
- Streambank Erosion
 - Increased peak flows from artificial drainage
 - Channelization/entrenchment of streams
- Reduction of wetlands and forested stream buffers

Old Woman Creek Pollutant Reduction Goal

Reduce sediment loading to OWC by 25% by 2015 = 263 tons/yr

Old Woman Creek Ecological Goal

Increase fish species diversity and population numbers of less tolerant fish species such as northern pike

ISSUE: AGRICULTURAL FIELD RUN-OFF

Decreases in species richness and relative abundance of native species (decline in native minnow and northern pike populations) in OWC correspond in part to changes in bed substrate due to increased sediment loading from agricultural practices in the Till Plain and Berlinville sub-basins.

Strategies

- Increase buffers and filter strips
 - Install new practices, widen existing practices totaling 200 acres
- Increase use of conservation tillage/residue management practices for 200 acres
 - Estimated load reduction (Avg. 1 ton per acre per year) = 200 tons per year
- Increase cover crop practices for 200 acres
 - Estimated load reduction (Avg. 2 tons per acre per yr) = 400 tons per year

ISSUE: STREAMBANK EROSION DUE TO LIVESTOCK

OWC has approximately 8500 linear feet of stream accessible to livestock. The highly erodible nature of soil found along the streambank has increased the likelihood of erosion caused by livestock. Many streambanks found within these areas are sparsely vegetated and have experienced moderate to severe erosion including bank failure. Although the amount of impacted stream by livestock access is relatively small, implementing strategies to improve these areas will not only reduce sediment but also reduce nutrient loading and enhance habitat.

Strategies

- Fence livestock from accessing stream (4,000 l. Ft.)
 - Estimated load reduction (Avg. 1.5 tons per acre per yr) = 15 tons per year
- Stabilize banks that have experienced severe erosion from livestock

ISSUE: EROSION, CHANNELIZATION/ENTRENCHMENT

Habitat alteration in the form of channelization and entrenchment encompasses approximately 23% of the watersheds drainage course (approximately 11 miles). Much of the channelized and entrenched sections are located in the headwaters of the watershed within the Berlinville and Till Plain sub-basins. Although some banks appear to be stable, many sections are experiencing moderate to severe bank erosion.

Table 33. Areas of observed streambank erosion in OWC.

| Stream | Location | Est. Length (l. ft.) | Erosion | Est. Load Reduction |
|------------------------|-----------------|-----------------------------|----------------|----------------------------|
| Brod Ditch | Bellamy Rd | 3,000 | Very Severe | 384 ton/yr |
| East Branch RM 12.5 | Liles Rd | 1,000 | Moderate | 108.8 ton/yr |
| West Branch RM 6.9 | Collins Rd | 500 | Moderate | 27.2 ton/yr |
| Elson Ditch | Ceylon Rd | 1,000 | Moderate | 54.4 ton/yr |
| Sherman Ditch | Andress Rd | 500 | Severe | 54.4 ton/yr |

Strategy

- Stabilize and enhance wildlife habitat in approximately 33% (2,000 l. ft.) of altered stream sections.

Table 34. Strategies to Reduce Sediment Pollution in the OWC watershed.

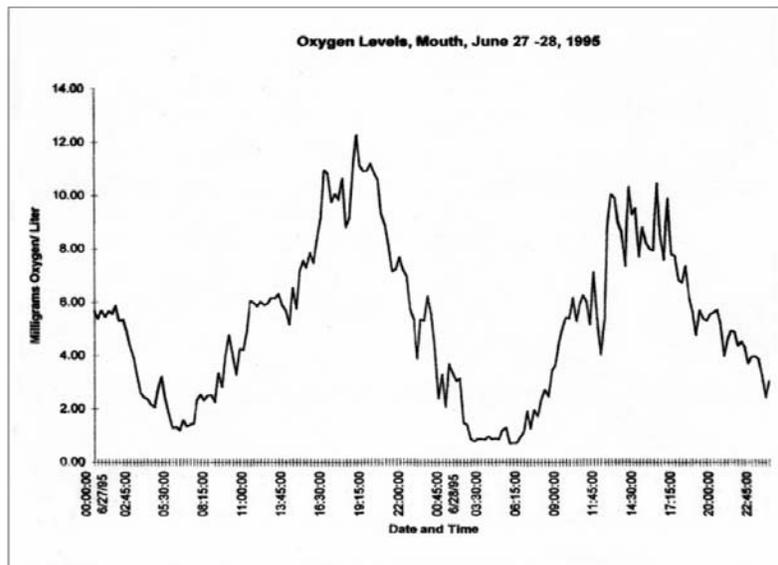
| Strategy | Description | Est. load reduction (Avg.) | Timeline | Resources | Funding | Performance Indicator |
|--|--|----------------------------|-----------|------------------------------------|---|--|
| Increase buffers and filter strips | Program to increase sign-up for farm-bill programs with additional incentive | 2 tons/ac/yr | 2012-2013 | NRCS SWCDs NACD | CRP, CSP, EQIP, Grant Funding | Increase buffer and filter strip usage by 10% each year |
| Increase Conservation Tillage/residue management | Program to increase sign-up for farm-bill programs with additional incentive | 0.26 tons/ac/yr | 2012-2013 | NRCS SWCDs NACD | CRP, CSP, EQIP, Grant Funding | Increase conservation tillage/residue management by 200 acres |
| Increase cover crop usage | Program to increase sign-up for farm-bill programs with additional incentive | 0.26 tons/ac/yr | 2012-2013 | NRCS SWCDs NACD | CRP, CSP, EQIP, Grant Funding | Increase cover crop usage by 200 acres |
| Livestock fencing | Program to provide sign-up incentive for farm-bill program | 1.5 tons/ac/yr | 2011-2012 | NRCS SWCDs NACD | CRP, CSP, EQIP, Grant Funding | Increase livestock exclusion by 4000 l.ft. |
| Streambank stabilization (livestock impact) | Assist cost of streambank stabilization as part of livestock exclusion plan | To be determined by site | 2011-2012 | | WHIP, FLEP, Grant Funding | Document number of l.ft. stabilized and QHEI scores pre and post project |
| Streambank stabilization (Development impact) | Stabilize and enhance approximately 25% of impacted stream (2000 l.ft.) | See table 33 | 2009-2010 | OWC NERR SWCDs Berlin Twp | Grant Funding | Document l.ft. of stabilized stream and QHEI scores pre and post project |

NUTRIENT POLLUTION

BACKGROUND

Eutrophication of the OWC estuary by nutrient pollution from improper waste water treatment and agriculture has altered the trophic dynamics of the ecosystem by increasing dissolved oxygen (DO) level fluctuations. Monitoring in the OWC estuary illustrated daily falls in DO below 2 mg/l- the minimum DO concentration that supports aquatic life. The rise and fall of DO in the estuary is consistent with photosynthesis and respiration cycles of algae.

As nutrient levels rise, (particularly phosphorus) in the estuary, algal populations increase, creating a “bloom” which can alter DO in the water column. Eutrophication of the receiving waters of OWC has resulted in lower fish populations and a shift in species composition of the estuary to an assemblage dominated by pollution tolerant species.



Phosphorus, particularly soluble reactive phosphorus (SRP), is responsible for algal

Figure 85: Graph illustrating extreme fluctuations of DO through a 24 hour period. Drops in DO fall below Ohio's water quality standard. (Herdendorf, et al. 2004)

blooms in the western and central Lake Erie basin causing the anoxic conditions of the Lake Erie Central Basin Dead Zone. Krieger (2002) found that total phosphorus and SRP entering Lake Erie from OWC in 1990 was 3,867 kg and 283.1 kg respectively. This however, was actually only about half the amount that entered the estuary from the upper watershed (5,813 kg and 521.2 respectively).

Nutrients enter OWC directly through animal and human waste as well as indirectly through run-off. Nutrients are a part of the soil matrix; as such, transportation of nutrients into the stream occurs through erosion during storm events. In order to restore the oxygen levels for aquatic life in the receiving waters, nutrient sources must be considered as a separate problem, although this can be correlated to sediment reduction in the watershed.



Figure 86: Main Street, Village of Berlin Heights (Feix)

Septic Systems. There are currently no centralized wastewater treatment facilities in the OWC watershed, even the communities of Berlin Heights and Oberlin Beach. Berlin Heights has a storm sewer system that transports partially treated wastewater from home sewage treatment systems serving approximately 670+ residents (TMDL, 2006). Although, the TMDL did not document water

quality impairments due to nutrient and bacterial pollution

resulting from inadequate wastewater treatment, the Erie County General Health District has documented several recreational swimming advisories related to elevated levels of *E. coli* found at the OWC barrier beach. This prompted an additional study of failing septic systems in the Berlin Heights and Oberlin Beach areas. These areas have systems more likely to malfunction due to age, design flaws, and improper maintenance. Preliminary data from the study have shown elevated levels of both bacteria and nitrogen found in the stream passing through the communities.

Suspected Causes of Nutrient Pollution:

- Inadequate wastewater treatment
- Agricultural run-off
- Livestock access to stream

Old Woman Creek Pollutant Reduction Goal

Reduce NH₃ and SRP loading to OWC by 33% by 2015 = see table 35

Old Woman Creek Ecological Goal

Increase fish species diversity and population numbers of less tolerant fish species such as northern pike

Table 35. Nutrient loading reductions proposed for OWC watershed.

| Nutrient | Total Load | WAP Load Reduction Goal | Percent Reduction | Ecological Goal |
|---------------------------|-------------|-------------------------|-------------------|-------------------------|
| SRP (Phosphorus) | 521 kg/yr | 173.73 kg/yr | 33% | Increase fish diversity |
| NH ₃ (Ammonia) | 3,225 kg/yr | 1085 kg/yr | 33% | Increase fish diversity |

ISSUE: WASTEWATER TREATMENT

Nitrogen loading from an estimated 47% failure rate of home sewage treatment systems found within the Berlin Heights and Oberlin Beach area has caused eutrophic conditions within the stream. The excess nutrients have created algal blooms resulting in harmful fluctuations of DO in the water column altering the species composition to species more tolerant of low oxygen conditions such as the Common carp (*Cyprinus carpio*).

Strategies:

- Quantify nutrient pollution loading from inadequate wastewater treatment and effects on local stream ecology.
- Identify possible solutions for improved wastewater treatment.
- Develop a community plan to address needs for improved wastewater treatment including funding objectives and appropriate timeline.

ISSUE: AGRICULTURAL FIELD RUN-OFF

Agricultural run-off (mainly row-crop) in the Till Plain sub-basin is a source for increased phosphorus and nitrogen loading, which has prevented attainment of several sites along the OWC mainstem. Strategies to address siltation occurring in the Till plain region of the watershed has already been discussed; therefore, this section will approach phosphorus reduction with the need to increase wetlands and riparian areas within the watershed. As previously stated, OWC estuary is a wetland complex that has the ability to greatly reduce the amount of phosphorus loaded into the stream before it reaches Lake Erie. Water quality of the west



Figure 87: Example of agricultural run-off in Erie County. (White)

branch where riparian forested cover is more abundant is generally better than that of the east branch where the forest has been removed. Creation of riverine wetlands and forested buffers in the Till Plain sub-basin would provide additional opportunities to assimilate pollutant loads before they leave the stream system.

Strategies:

- Increase nutrient management techniques for crop production.
- Stress the importance of maintaining stream buffers and filter strips
- Create small wetland complexes directly connected to the upper till plain drainage ways
- Utilize new techniques in agricultural water table management

ISSUE: ANIMAL WASTE, LIVESTOCK ACCESS

Nitrogen loading from animal waste where livestock has full access to the creek has contributed to the nutrient enrichment of OWC. Fluctuations in DO levels as a result of algal blooms have transitioned the fish community to species more tolerant of oxygen stress. Currently, approximately 8,500 linear feet of OWC stream would benefit from livestock restrictions. The highly erodible nature of the streambank makes this an important and attainable goal. Because the few livestock operations found within the watershed are small (less than 100 head), this issue is not considered to be the largest contributor to nutrient loading. As such, the implementation strategies have been previously described in this chapter.



Figure 88: Livestock in OWC watershed. (Hohman)

Table 36. Strategies for Nutrient Pollution Reduction in the OWC Watershed.

| Strategy | Description | Est. load reduction (Avg.) | Timeline | Resources | Funding | Performance Indicator |
|--|--|----------------------------|-----------|--|--|--|
| Septic System Study | Quantify nutrient and bacterial pollution in OWC and relate to septic system function in Berlin Heights area | N/A | 2008 | ECGHD DOES OWC NERR SWCDs BHVC | ODNR Funding | Study documentation and presentations |
| Assess various solutions for improved wastewater treatment | Develop a cost analysis of wastewater treatment options for the Village of Berlin Heights | N/A | 2009 | ECGHD BHVC | ODNR Funding | Final assessment document |
| Wastewater treatment improvement plan | Develop a plan that outlines improvement goals, funding objectives, and timeline | N/A | 2009-2010 | ECGHD DOES OWC NERR SWCDs BHVC | Local and Grant Funding | Final plan document |
| Increase nutrient management practices | Develop a program to increase conservation program sign-up. | | 2013-2014 | NRCS SWCDs RC&D | CRP, CSP, EQIP, Grant Funding | Increase producer participation by 25% |
| Continued conservation program participation campaign | Work to maintain and renew contracts for water quality resource concerns | N/A | Ongoing | NRCS SWCDs RC&D | Local support | No net loss in current BMP acreage |
| Small wetland creation | Select an area to create a linear series of small wetlands along the east branch of OWC (or tributary). | To be studied | 2011-2014 | NRCS SWCDs RC&D OWC NERR | CRP, EQIP, WHIP WRP Grant Funding | Create approx. 20 acres of new wetland |
| Water table management project | Provide a demonstration of underground irrigation system that utilizes wetland/reservoir system. | To be studied | 2010-2013 | SWCDs OWC NERR RC&D | Grant Funding | Install at least one demo project |

HABITAT AND FLOW ALTERATION

BACKGROUND

Habitat and flow alteration through manipulated drainage and the conversion of forest and wetlands to agricultural and urban land use have resulted in increased “flashiness” of OWC and decreased base flow in many sections of the stream. Before settlement, much of the OWC landscape consisted of dense forests of oak, chestnut, hickory, ash, walnut, sycamore, and tuliptree (Herdendorf, et al, 2004). In the 19th century, the landscape began to change from forest to agriculture as settlers took advantage of the rich sandy soils



Figure 89: Alteration of stream habitat by removal of vegetation and channelization for residential development (Hohman)

and unique climate created by Lake Erie. Agricultural land use, as in many areas of the Great Lakes basin, required artificial drainage and forest clearing prior to crop production (Buchanan, 1982). Removal of upland forest has resulted in changes in fish populations in the watershed directly related to increases in siltation and turbidity due to increased storm flow (Herdendorf et al., 2004). The Till Plain sub-basin differs from the other basins in that it has the lowest percent



Figure 90: Low water in east branch of OWC during summer months (Hohman)

of riparian forest cover in the OWC watershed and greatest amount of modified stream morphology. With increased storm flows in spring and areas of stagnant flow in summer, the Till Plain area is thought to have the highest variability of flow in the watershed (Buchanan, 1982). It was observed by Buchanan further observed that torrential flow and out of bank flooding was visible only in the upper basin during significant storm events compared to the lower basin.

In addition to agricultural drainage, urbanization has also altered the flow regime of OWC. Urbanization

converts permeable landscapes (vegetative cover) to impermeable landscapes (buildings and pavement) which in turn reduces the infiltration of surface water and increases run-off rate and volume. Increased run-off due to land use change, artificial drainage, and impermeable surfaces have caused “flashiness” of the stream to occur more frequently (Baker, et al. 2004).

Increased run-off due to land use change, artificial drainage, and impermeable surfaces has also increased “flashiness” of the stream (Baker, et al. 2004). Stream flashiness refers to the frequency and rapidity of short term changes in stream flow usually associated with storm-events. Habitat quality is linked to stream flashiness because the flow regime of a stream has multiple implications on stream ecology. Increased erosion, pollution, and alteration of natural flow patterns associated with flashiness add to stressors that many native species



Figure 91: Channelized tributary of Old Woman Creek for agricultural drainage. (Hohman)

cannot tolerate, which results in changes in species diversity in the system. As such, restoration of natural streamflow regimes are often considered an essential component to resorting aquatic life in the system (Baker et al. 2004).

Suspected Causes of Habitat and Flow Alteration

- Increased peak flows from artificial drainage
- Conversion of wetlands and forested stream buffers to other land uses
- Increased impermeable surfaces

Old Woman Creek Habitat Goals

- Increase forest cover by 100 acres within 300ft of stream by 2013.
- Protect 100 acres forested area in the watershed through use of conservation programs and easements
- Increase watershed wetlands by 20 acres
- Create water management demonstration area

Old Woman Creek Ecological Goal

Restore the stream flow regime to OWC that would increase diversity of aquatic life.

ISSUE: WETLAND AND WOODLAND LOSS



Figure 92: Vegetation recently removed from stream channel after herbicide application (Hohman)

OWC has a 10 year average Richard-Baker Flashiness Index (RB-Index) of 0.905, which is ten times higher than a comparable reference watershed Augusta Creek (Michigan). This watershed is similar to OWC in size, land use, and free flowing nature; however, Augusta Creek has extensive wetlands surrounding its headwaters and greater forested stream buffer thus reducing the flashy nature of storm induced flow. Increasing wetlands and forested riparian buffers in the upper reaches of the OWC watershed over time will

result in lowering the RB-Index of the stream (Baker, et al. 2004).

Strategies:

- Restore 5 acres of floodplain hardwoods
- Improve forested corridor of stream with riparian buffer planting program in the Till Plain and Lake Plain sub-basin
- Improve habitat through “natural channel” construction with plantings of native wetland flora to slow flows and increase habitat

ISSUE: ARTIFICIAL DRAINAGE

Artificial drainage and modified stream morphology within several reaches of OWC has increased “flashiness” of storm flows, increasing flow rates to 830 cu ft/s or 40 times higher than the average flow of 10-20 cu ft/s. Increased groundwater recharge and riparian storage capacity of stream flow will reduce the variability of flow in wet weather and dry weather months.

Strategies:

- Improve groundwater infiltration with the use of water table management techniques in the Till Plain and Berlinville sub-basins
- Reduce peak flow through “natural channel” construction with plantings of native wetland flora to slow flows and increase habitat

Table 37. Strategies to Increase Habitat and Restore Natural Flow Regimes in OWC watershed.

| Strategy | Description | Estimated load reduction (Avg.) | Timeline | Resources | Funding | Performance Indicator |
|---|--|---------------------------------|-----------|------------------------------|--|--|
| Hardwood reforestation in OWC NERR | Plant native hardwoods in 5 acre riparian buffer as part of invasive species removal project | N/A | 2009-2011 | OWC NERR EMP ESWCD | ODNR | Establishment of 5 acres of forested riparian buffer |
| Riparian buffer reforestation program | Provide incentive and cost share for restoring forested riparian buffers | 1-2 kg per ton/acre/year | 2012-2013 | SWCDs ODNR EMP BTCC | CRP, CSP, EQIP, FLEP, WHIP, Forest Legacy Program, Grant Funding | Restore 100 acres of forested cover within 300 linear feet of the stream |
| “Natural Channel” ditch demonstration project | Select an area to demonstrate “natural channel” design for agricultural ditches | To be studied | 2011-2014 | OWC NERR SWCDs ODNR | Grant Funding | Install at least one ditch demonstration project |

COMMUNITY ENGAGEMENT

BACKGROUND

Community based-watershed management is empowering local individuals, groups, and institutions to become engaged in identifying and addressing issues that affect their watershed. A community based watershed-approach allows for all-inclusive perspectives of the physical, economic, and social aspects of watershed functions. A scientific basis is needed for selecting management decisions; however, this alone will not ensure long-range success of the plan. A community based approach opens the management process to consider social and economic benefits of treatment strategies.



Figure 93: Watershed planning public meeting (Hohman)

The National Academy of Sciences (NAS) has offered several reports on the importance of public participation in decision-making process of environmental issues. These reports stem from criticism implying that requiring public participation only slows the decision-making process through distortion of the process, the science, and implementation of the proposed policy. Consequently, the NAS found that, when done correctly, involving the public actually improves the quality of the decision being made and increases the legitimacy of associated policies, which, in turn, increases the effectiveness of implementation. Engaging the public in decision-making and planning creates opportunities for citizens to become more informed about local environmental issues.



Figure 94: Volunteers demonstrating the enviroscape model to teach residents about non-point source pollution (Hohman)

Knowledge gained through this process better prepares citizens to continue to participate in their communities decisions for future growth and issue resolution.

The approach for community engagement in OWC has consisted of a series of education and outreach opportunities. Using many engagement options ensures that the public has multiple points of entry to the watershed program. These engagement tools are evaluated to adjust stewardship opportunities provided for future planning.



Figure 95: Various FCT engagement events: Wildflower walk (left), Volunteer stream monitoring training (top right), Stream clean-up (bottom right). (VanZoest, Hohman, Riddle)

Table 38. Overview of community engagement tools utilized during 2007-2008.

| Engagement Tool | Opportunity Type | Mode of engagement | Benefits | Challenges |
|---------------------------|------------------------------|---------------------------|---|---|
| Newsletter | Education/outreach | Indirect | Ability to educate, highlight events, and accomplishments | No guarantee it is read |
| Website | Education/outreach | Indirect | Provides source for detailed information | Internet is a not a main tool for information in this local context |
| Technical sub-committees | Technical Advisory | Direct | Utilizes stakeholder knowledge and skills | Time commitment makes it difficult to recruit and retain |
| Public Meetings | Education/Feedback | Direct | Opportunity for public discussion of topics | May not be well attended |
| FCT Council Lunch | Education/Feedback | Direct | Stakeholders focus on “Big Picture” and get motivated | Requires moderate time commitment |
| Official Public Meetings | Education/Outreach | Direct | Call for specific involvement | Short timeframe for topic |
| Focus Groups | Feedback | Direct | Selected group for specific comment needs | Specific results – better applied to specific project planning |
| Residents Survey (Mailed) | Feedback | Indirect | Allows for a broad range of questions | Volunteer participation required |
| Volunteer Opportunities | Education/Active Involvement | Direct | Data collection, clean-up, etc. | Requires commitment of time, may require training |
| Educational Workshops | Education | Direct | Increases community understanding of local water issues | Needs to be tailored to specific audience |

OPPORTUNITY STATEMENT: EDUCATION AND OUTREACH

Increasing understanding of the connection of human activity and watershed function by providing opportunities for individual participation is vital to the community-based watershed approach. Educational opportunities for local residents provided by the FCT partners increase understanding of stream ecology, pollutant introduction, proven and innovative BMPs, and how the community benefits from improving and protecting OWC.

Strategies

- Outreach and Communication
 - “Up a Creek” Newsletter
 - www.Firelandtributaries.org website
 - Watershed signage program
- Volunteer Stream Monitoring Program
 - Tribs Team adult monitoring program
 - Chemical, habitat, biological (macroinvertebrate)
 - Develop youth monitoring program
 - Chemical, habitat, biological (macroinvertebrate)
- Watershed Stewardship Education
 - Erie Soil and Water Conservation Banquet – “Innovative Ideas” theme; Agriculture and Urban (Alternating years)
 - Promotion of OWC NERR Estuary Explorations
 - OSU Stone Lab Stream Ecology for Teachers Workshop – Huffman Reserve
 - Homeowner Stewardship Workshop Series
 - Composting
 - Rain Gardens/Rain Barrels
 - Septic system maintenance
- Community/Stream Clean-up events in conjunction with “Keep America Beautiful” and “International Coastal Clean-up Day”
 - Beach clean-up
 - Stream clean-up
 - Community litter clean-up



Figure 96: FCT Quarterly Newsletter

Table 39. Education and Outreach Strategies for the OWC and FCT Watersheds

| Theme | Event Type | Location | Audience | Number of Events | Season | Funding | Lead Partner |
|---------------------------|--------------------------------|---|---------------------------------|------------------|----------------|----------------------|---------------------------|
| "Up a Creek" | Newsletter | Mailed/internet | OWC residents & FCT partners | Quarterly issues | Quarterly | OWC NERR, DOW | ESWCD |
| Website | Website | firelandtributaries.org | Adult/Youth | N/A | Spring-Fall | local | ESWCD |
| Watershed Signage Program | Outreach | FCT Watersheds, Specifically Pipe and OWC | Residents | N/A | N/A | local, Grant funding | ESWCD |
| Monitoring | Workshop/Volunteer Opportunity | Classroom and Stream | Residents/Adult | 1-2/yr | Spring/Fall | local, grant funding | Monitoring Committee, FCT |
| Monitoring | Workshop/Volunteer Opportunity | Classroom and Stream | Students/Family | 1/yr | Summer | local | OWC NERR |
| Clean-up | Volunteer opportunity | Coastline/ Stream/ neighborhood | Adult/Youth | 1/yr | Spring | local, grant funding | DOES |
| Clean-up | Volunteer opportunity | Coastline/Stream/ neighborhood | Adult/Youth | 1/yr | Fall | local, grant funding | OWC NERR |
| Earth Day Extravaganza | Public Event | TBD | Adult/Youth | 1/yr | Spring | TBD | DOES |
| Harvest Happenings | Public Event | EMP Osborn Park | Adult/Youth | 1/yr | Fall | TBD | EMP |
| Composting | Workshop | Classroom | Adult | Every 2 years | | local | DOES |
| Rain Gardens | Workshop | Classroom | Adult | 2/yr | Spring | local | ESWCD |
| Rain Barrels | Workshop | Classroom | Adult | 1-3/yr | Spring/ Summer | Registration fee | ESWCD |
| Septic Systems | Workshop | Classroom | Adult | Once/2yrs | Fall | local | ECGHD |
| Stormwater BMP Tour | Tour | Watershed/ Counties | Public Officials/ Professionals | Once/2yrs | Spring-Fall | grant funds | ESWCD |

BALANCED GROWTH

BACKGROUND

The impacts of future residential development in the watershed could lead to additional water quality impairments and habitat loss. A demographic analysis performed in 1986 projected steady increases in population and new development following the completion of state Route 2 in 1989 (Holly, 1986). While rapid population growth has not occurred as predicted, driving forces indicate that the area is still likely to change. Slow yielding water wells may have been a primary deterrent to Holly's forecasted growth (Klarer, per com). However, recent installation of water lines along arterial streets has removed this obstacle to residential development in some areas.

Due to a decline in family farming, more farmland in the watershed is becoming available for residential development. In addition, the OWC watershed lies within acceptable commuting distance of Cleveland and Toledo and the local school district has a strong record of academic achievement. Taken together, these factors make the watershed a highly regarded place for individuals seeking a more



Figure 97: New housing replacing farmland in OWC watershed. (Feix)

“rural” lifestyle. A pattern of low density, rural residential development is already underway along some of the arterial roads in the area such as Route 61, Mason Road, and Berlin Road. In 1993, impervious surface area in the OWC watershed ranged from 4.95-11.6%. By 2003, imperviousness had increased to 5.05-13.55% (Primack, 2004). This range is approaching the threshold at which water quality degradation due to development has been documented (Brabec, 2002).

There are no centralized municipal wastewater treatment systems within the OWC watershed. The provision of county water in previously underserved areas could bring about additional residential development and home sewage treatment systems. If not properly maintained, home septic systems may fail and add bacteria and nutrients to OWC and its tributaries.

The Lake Erie Commission describes balanced growth as a strategy to protect and improve Lake Erie and its basin to ensure to integrity of the economy,

ecology, and social well being of the community. Because the OWC watershed has not experienced the rate of growth suggested by Holly (1986), using balanced growth principles will allow for a proactive approach to community sustainability.

10 Guiding Principles for a Sustainable Lake Erie Watershed

Attaining a living equilibrium between a strong, diversified economy and a healthy Lake Erie ecosystem

Activities in the Ohio Lake Erie watershed should:

1. Maximize investment in existing core urban areas, transportation, and infrastructure networks to enhance the economic vitality of existing communities.
2. Minimize the conversion of green space and the loss of critical habitat areas, farmland, forest and open spaces.
3. Limit any net increase in the loading of pollutants or transfer of pollution leading from one medium to another.
4. To the extent feasible, protect and restore the natural hydrology of the watershed and flow characteristics of its streams, tributaries, and wetlands.
5. Restore the physical habitat and chemical water quality of the watershed to protect and restore diverse and thriving plant communities and preserve rare and endangered species.
6. Encourage the inclusion of all economic and environmental factors into cost / benefit accounting in land use and development decisions.
7. Avoid development decisions that shift economic benefits or environmental burdens from one location to the other.
8. Establish and maintain a safe, efficient, and accessible transportation system that integrates highway, rail, air, transit, water, and pedestrian networks to foster economic growth and personal travel.
9. Encourage that all new development and redevelopment initiatives address the need to protect and preserve access to historic, cultural, and scenic resources.
10. Promote public access to and enjoyment of our natural resources for all Ohioans.

OPPORTUNITY STATEMENT: WATERSHED-BASED COMMUNITY PLANNING

The comprehensive plan for Erie County is over 10 years old and is in need of an evaluation and update. Moreover, there is currently no comprehensive land use plan for Berlin Township, Berlin Heights, or Townsend Township, which comprise 95% of the watershed. The development of a community-based comprehensive plan utilizing balanced growth principles and best local land use practices will strengthen community stewardship and facilitate sustainable growth in the Old Woman Creek watershed.



Figure 98: Undeveloped wooded area on west branch of Old Woman Creek (Hohman)

Strategies

- Explore various land protection options such as steep slope, wetland, woodland, farmland, etc. through zoning and easements and provide recommendations for future planning documents
- Increase understanding and awareness of construction site BMPs with newly adopted stormwater regulations
- Assist local communities in developing a watershed-scale comprehensive plan utilizing the balanced growth principles to identify priority conservation and priority development areas.

Table 40. Watershed-based community planning strategies for OWC watershed.

| Strategy | Description | Estimated load reduction (Avg.) | Timeline | Resources | Funding | Performance Indicator |
|--|--|---------------------------------|-----------|---|-----------------------------------|---|
| Zoning Protection Recommendations | Develop a workshop with public officials and staff to understand ways to use zoning as a tool for watershed protection | N/A | 2009-2011 | OWC NERR ESWCD Townships BHVC | local | Zoning Workshop |
| Increase understanding of stormwater regulations | Develop a BMP tour that uses real life examples to illustrate stormwater regulations in action. | N/A | 2012-2013 | SWCDs ODNR CTP | Local, CTP | Stormwater BMP Tour with emphasis on regulation implementation |
| Assist local communities with a “watershed scale” comprehensive plan | Develop specific recommendations for utilizing balanced growth initiative in future development of OWC watershed | N/A | 2011-2014 | OWC NERR SWCDs ERPC Townships BHVC LEC CTP | Local, CTP Grant Funding | Submit recommendations as part of comprehensive planning process for area |

WATERSHED RESEARCH

BACKGROUND



Figure 99: Old Woman Creek National Estuarine Research Reserve Visitor's Center and Laboratory

Current and future planning efforts have an opportunity to benefit from the partnership with OWC NERR through research and monitoring conducted both internally and associated with a broader academic community. The NERR provides a mechanism for addressing scientific and technical aspects of coastal management problems through a comprehensive, interdisciplinary, and coordinated approach of both state (ODNR-DOW) and federal (NERRS) research objectives. Research and

monitoring programs, including the development of baseline information, form the basis of this approach. Research and monitoring activities are guided by the reserve system research and monitoring plan which identifies goals, priorities, and implementation strategies. This approach, when used in combination with education and outreach, will help ensure the availability of scientific information with long-term, consistency and utility for planners, decision-makers, and citizens to use in protecting or improving local water resources.

GOALS FOR RESEARCH AND MONITORING at OWC NERR

Goal 1: Develop a comprehensive scientific understanding of natural functions and processes occurring within the estuary, watershed, and adjacent Lake Erie, and to determine the impact of human activities on these systems

Goal 2: Provide information critical for the proper management, protection, and restoration of freshwater estuaries and other coastal areas within the Lower Great Lakes

OPPORTUNITY STATEMENT: WATERSHED RESEARCH

A strong partnership with the OWC NERR offers the possibility of proposing potential research objectives based on the needs for identification and evaluation of future watershed planning and implementation strategies. These strategies, derived from information gaps identified through the watershed inventory process, are parallel to research objectives laid out in the Management Plan for OWC NERR. As such, these areas of interest will increase the understanding of the watershed approach for the Firelands area while meeting specific management objectives of the OWC estuary.

Research Objective: Assess BMP effectiveness and mitigation thresholds for urban and agricultural non-point source pollutants

Research Objective: Correlate wetland size and pollutant assimilation

Research Objective: Characterize effects of retained agricultural drainage for use in sub-irrigation to maintain stream flow in OWC.

Research Objective: Identify long-term variability of water quality and land use change.

ADDITIONAL WATERSHED MONITORING

BACKGROUND

Watershed monitoring is an essential way to develop critical information that helps to characterize a watershed, develop planning objectives, and evaluate implementation. There are many different forms of monitoring; land use change, water quality, and species composition and distribution are among the most commonly used in watershed management. Monitoring can be completed through the use of professional organizations or through the use of trained volunteers depending on the funding and capabilities of the watershed program. While professional organizations may provide more accurate and precise data, it is often very costly. Volunteer monitoring is less expensive, however but may not offer the same level of credible data as professional monitoring. Volunteer monitoring can



Figure 100: FCT Stream Monitoring Kit (Hohman)

strengthen watershed management efforts as it serves as an engagement tool for community participation. The FCT makes use of its diverse partnerships to develop and conduct professional and volunteer forms of watershed monitoring.

Stream Monitoring. Partnerships developed through the efforts of the FCT program have lead to additional monitoring efforts in the OWC watershed and FCT area. In 2007, a volunteer stream monitoring group (Tribs Team) was formed to begin monitoring chemical parameters of OWC and Pipe Creek watersheds. A project study plan was developed and volunteers trained to conduct selected sampling protocols. Local laboratories have also partnered in this effort to supplement information that cannot be collected in the field.

OPPORTUNITY STATEMENT: VOLUNTEER MONITORING

Volunteers are utilized in many watersheds to provide essential water quality information for watershed programs that do not have the capacity to hire additional staff or funding to hire consultants. Through accreditation of the Ohio EPA Credible Data Program, the FCT Tribs Team data will assist with problem identification and program evaluation.

Monitoring Objective: Monitor chemical parameters in upper reaches of OWC to complement and expand coverage of the estuarine monitoring efforts of the OWC NERR.

Monitoring Objective: Monitor biological and habitat attributes of selected stream reaches for problem identification and program evaluation.

Agricultural Monitoring. Conduct a tillage transect to observe and discuss the conditions, needs, and accomplishments of the initiated practices. A tillage transect affords conservation agencies and partners the ability to track trends in conservation tillage, soil erosion, residue cover, energy consumption, crop rotations and even carbon sequestration.

OPPORTUNITY STATEMENT: SWCD MONITORING

The cropland roadside survey, or tillage transect survey method, was designed to gather information on various agricultural practices, primarily tillage and crop residue management systems. One purpose of the transect survey is to provide accurate data on tillage systems and crop residue cover for the NRCS National Resource Inventory, making it an ideal tool for assessment as well as measuring progress for locally led conservation efforts.



Figure 101: Conventional tilled agricultural field after harvest. (Hohman)

Monitoring Objective: Initiate tillage transect survey methods of agricultural practices to identify trends in tillage practices and crop production type.

Chapter 7. Budget

SUMMARY

This budget was calculated using static estimates for various implementation strategies over a six year period. As such, this budget does not reflect potential increases due to inflation. Agricultural BMP estimates are taken from NRCS unit cost projections and documented case studies. Additional estimates, including coordinator and consultant time, printing, etc., were developed from previous grant application budget details, FCT fiscal reports, and SWIMS (Soil and Water Information Management System) timesheet records. Each strategy's cost estimate listed in this section is to be used as a reference for future grant applications and other funding alternatives. A more detailed budget may be warranted to reflect changes in project detail and current economic status.

The budget is represented in several ways including total budget for the FCT program and OWC WAP plan implementation, and a more detailed breakdown of each strategy's project cost. The cost projections for each strategy are grouped by the pollution reduction or opportunity in mind to parallel the previous section.

Table 41. FCT 6-year program budget.

| Category | Cost | Indirect (10%) | Total Cost |
|---|------------------|-------------------|------------------|
| Coordinator Salary and Benefits | \$390,000 | \$39,000 | \$429,000 |
| Implementation of WAP strategies (less coordinator) | \$419,208 | | \$419,208 |
| Overhead | \$60,000 | \$6,000 | \$66,000 |
| Total | \$869,208 | \$45,000 | \$914,208 |

Table 42. OWC WAP 6-Year Implementation Budget Summary

| Project Category Detail | Total Cost |
|-------------------------|------------------|
| Sediment Reduction | \$114,497 |
| Nutrient Reduction | \$110,511 |
| Habitat Enhancement | \$83,820 |
| Watershed Education | \$109,395 |
| Planning and Research | \$82,590 |
| Volunteerism | \$115,500 |
| Total | \$616,313 |

Table 43. Sediment reduction strategies

| Strategy | Program Manager | BMP Cost Unit | Unit | Project Size | Total BMP | Printing | Marketing/ Mailings | Travel | Signage | Sub-Total | Indirect (10%) | Total |
|---|-----------------|---------------|-------------|--------------|-----------|----------|---------------------|--------|---------|-----------|----------------|------------------|
| Increase Buffers and Filter Strips | \$1,400 | \$239.69 | Acre | 200 | \$47,938 | \$100 | \$500 | \$75 | | \$50,013 | \$5,001 | \$55,014 |
| Increase Conservation Tillage/Residue Management | \$1,400 | \$10 | Acre | 200 | \$2,000 | \$100 | \$500 | \$75 | | \$4,075 | \$408 | \$4,483 |
| Livestock Fencing Streambank Stabilization (Livestock Impact) | \$1,400 | \$2 | Feet | 4000 | \$8,000 | | \$50 | \$100 | \$300 | \$9,850 | \$985 | \$10,835 |
| Streambank Stabilization (Livestock Impact) | \$2,800 | \$600 | Acre | 3 | \$1,800 | | \$50 | \$100 | | \$4,750 | \$475 | \$5,225 |
| Streambank Stabilization (Development Impact) | \$4,200 | \$15 | Linear foot | 2000 | \$30,000 | \$500 | \$250 | \$150 | \$300 | \$35,400 | \$3,540 | \$38,940 |
| | | | | | | | | | | | Total | \$114,497 |

Table 44. Nutrient reduction strategies

| Strategy | Program Manager | BMP Cost Unit | Unit | Project Size | Total BMP | Marketing/ Mailings | Travel | Sub-Total | Indirect (10%) | Total |
|----------------------------------|-----------------|---------------|------|--------------|-----------|---------------------|--------|-----------|----------------|------------------|
| Agricultural nutrient management | \$1,400 | \$10 | Acre | 200 | \$2,000 | \$100 | \$100 | \$3,600 | \$360 | \$3,960 |
| Wetland creation project | \$5,600 | \$168.22 | Acre | 20 | \$3,364 | \$100 | \$150 | \$9,214 | \$921 | \$10,136 |
| Water table management project | \$7,000 | \$4,000 | Acre | 20 | \$80,000 | \$500 | \$150 | \$87,650 | \$8,765 | \$96,415 |
| | | | | | | | | | Total | \$110,511 |

Table 45. Habitat improvement strategies

| Strategy | Program Manager | BMP Cost Unit | Unit | Project Size | Total BMP | Printing | Marketing/ Mailings | Equipment | Sub-Total | Indirect (10%) | Total |
|-------------------------------------|------------------------|----------------------|-------------|---------------------|------------------|-----------------|----------------------------|------------------|------------------|-----------------------|-----------------|
| Riparian buffer restoration program | \$4,200 | \$650 | Acre | 100 | \$65,000 | \$100 | \$250 | | \$69,550 | \$6,955 | \$76,505 |
| Hardwood restoration in OWC NERR | \$2,800 | \$650 | Acre | 5 | \$3,250 | | \$100 | \$500 | \$6,650 | \$665 | \$7,315 |
| | | | | | | | | | | Total | \$83,820 |

Table 46. Educational opportunities

| Opportunity Strategy | Program Manager | Consultant | Event Cost | Printing | Marketing/ Mailings | Events/ Mailings/ Updates | Sub-Total | Indirect (10%) | Total | |
|--|------------------------|-------------------|-------------------|-----------------|----------------------------|----------------------------------|------------------|-----------------------|--------------|------------------|
| Newsletter | \$1,400 | | | \$800 | \$200 | 24 | \$57,600 | \$5,760 | \$63,360 | |
| Website | \$700 | \$500 | | | \$50 | 6 | \$7,500 | \$750 | \$8,250 | |
| Rain Garden Workshop | \$500 | | | \$500 | \$100 | 6 | \$6,600 | \$660 | \$7,260 | |
| Rain Barrel Workshop | \$700 | | | \$250 | \$100 | 6 | \$6,300 | \$630 | \$6,930 | |
| BMP Tour | \$2,800 | | \$1,500 | \$100 | \$250 | 2 | \$9,300 | \$930 | \$10,230 | |
| Septic System Workshops | \$1,400 | \$500 | \$100 | \$100 | \$250 | 2 | \$4,700 | \$470 | \$5,170 | |
| Zoning Tools for Watershed Protection Workshop | \$4,200 | \$1,500 | \$500 | \$1,000 | \$250 | 1 | \$7,450 | \$745 | \$8,195 | |
| | | | | | | | | | Total | \$109,395 |

Table 47. Planning and research strategies

| Opportunity Strategy | Program Manager | Consultant | Printing | Marketing/ Mailings | Sub-Total | Indirect (10%) | Total |
|---------------------------------------|------------------------|-------------------|-----------------|----------------------------|------------------|-----------------------|-----------------|
| Comprehensive planning | \$5,600 | \$5,000 | \$250 | \$250 | \$11,100 | \$1,110 | \$12,210 |
| WAP revision | \$14,000 | \$2,000 | \$2,000 | \$500 | \$18,500 | \$1,850 | \$20,350 |
| GIS Mapping | \$7,000 | \$10,000 | \$1,000 | | \$18,000 | \$1,800 | \$19,800 |
| Wastewater treatment improvement plan | \$2,800 | \$20,000 | \$500 | \$250 | \$23,550 | \$2,355 | \$25,905 |
| Hazardous Spill Response Plan | \$2,000 | \$3,000 | \$500 | \$250 | \$5,700 | \$575 | \$6,325 |
| | | | | | | Total | \$84,590 |

Table 48. Volunteer programs

| Opportunity Strategy | Program Manager | Printing | Marketing/ Mailings | Equipment Total | Miscellaneous | Number of Events | Sub-Total | Indirect (10%) | Total |
|-----------------------------|------------------------|-----------------|----------------------------|------------------------|----------------------|-------------------------|------------------|-----------------------|------------------|
| Stream Clean-ups | \$2,800 | \$250 | \$250 | \$500 | \$500 | 12 | \$46,100 | \$4,610 | \$50,710 |
| Volunteer Monitoring | \$5,600 | \$1,000 | \$500 | \$6,000 | \$500 | 6 | \$51,600 | \$5,160 | \$56,760 |
| Restoration Activities | \$1,400 | \$100 | \$100 | \$500 | \$100 | 4 | \$7,300 | \$730 | \$8,030 |
| | | | | | | | Total | | \$115,500 |

Chapter 8. Coastal Management Measures

Purpose

In this chapter, the reader will find a review of the applicability of management measures specified in the Coastal Nonpoint Pollution Control Program and implementation strategies to address those measures within the Old Woman Creek watershed. Many objectives address more than one management measure. To simplify this review process, only primary objectives are listed for each measure. A table at the end of this chapter identifies where overlap in the objective strategies exist.

Chapter Acknowledgements

This chapter was prepared utilizing sections from *The Ohio Coastal Nonpoint Pollution Control Plan* and by the watershed coordinator and the FCT partners.

COASTAL NONPOINT POLLUTION CONTROL IN OWC

As stated in Chapter 3, the Coastal Nonpoint Pollution Control Program (CNPCP) is a nonpoint source management program specified for restoring and protecting coastal waters from specific categories of nonpoint source pollution. Administered by the ODNR Division of Soil and Water Conservation, the Division requires Watershed Action Plans being developed for Lake Erie watersheds under the Watershed Coordinator Grant Program to include implementation strategies to address management measures identified within CNPCP.

Old Woman Creek watershed is a sub-basin of the greater Lake Erie watershed. As such, the land use and overall health of the watershed has direct impact on the integrity of Lake Erie. Although Old Woman Creek is mostly an agricultural watershed, there is also a low density urbanized area near the center of the basin (Berlin Heights). Management measurements in this section will address both agricultural and urbanized areas of the entire watershed with an exception to household sewage treatment systems which will focus on the area of highest density (Berlin Heights and surrounding development in Berlin Township).

Applicable Management Measures

- New Development
- Watershed Protection
- Site Development
- Existing Development
- New Household Treatment Systems
- Operating Household Treatment Systems
- Planning, Siting, Developing Road, Highways, and Bridges
- Bridges (Local Only)
- Operation and Maintenance Program for Existing Modified Channels - Protect Surface Water and Restore In-Stream and Riparian Habitat
- Eroding Streambanks and Shorelines

The Old Woman Creek watershed does not have any man-made impoundments impacting surface water quality or in-stream and riparian habitat thus exempting it from the management measure addressing dams.

New Development Management Measure. This management measure is intended to accomplish the following: (1) decrease the erosive potential of increased runoff volumes and velocities associated with development-induced changes in hydrology; (2) remove suspended solids and associated pollutants entrained in runoff that result from activities occurring during and after development; (3) retain hydrological conditions to closely resemble those of the predisturbance condition; and (4) preserve natural systems including in-stream habitat.

Approximately 80% of the watershed is located within Erie County, which is considered a Phase II Community by the Ohio EPA. Although, the watershed itself is not located within the permitted urbanized area of the Phase II program, stormwater regulations that are administered by the County Engineer are ubiquitous for areas under jurisdiction of the county. Recently the Erie County stormwater regulations for pre and post-construction stormwater management have been revised to include measures to maintain and improve water quality of developed sites where applicable. This document stresses preserving the use of natural hydrology in the stormwater design, maintaining or improving hydrology as not to negatively impact the receiving waters, and utilize structural and non-structural BMPs for reducing erosion and sedimentation that may result from the development. These regulations currently cover unincorporated areas of the county which include much of the Old Woman Creek watershed. The regulations do not cover the areas of the watershed within the Village of Berlin Heights or Huron County. Adoption of these regulations or similar documents by the unregulated communities would fully address this management measure within the watershed.

Primary Objectives

- Implementation of upgraded Stormwater Regulations for Erie County
- Adoption of Erie County Stormwater Regulations (or similar document) by Village of Berlin Heights and Huron County

Additional Strategies

- Hold one educational event for public officials and professionals to increase knowledge of stormwater program significance and steps initiating a stormwater program
- Identification of local and regional watershed approach stormwater trainings. Encourage a representative from each district attend at least one event yearly.

Watershed Protection Management Measure. The purpose of this management measure is to reduce the generation of nonpoint source pollutants and to mitigate the impacts of urban runoff and associated pollutants that result from new

development or redevelopment, including the construction of new and relocated roads, highways, and bridges. The measure is intended to provide general goals for States and local governments to use in developing comprehensive programs for guiding future development and land use activities in a manner that will prevent and mitigate the effects of nonpoint source pollution.

Develop a watershed protection program to:

1. Avoid conversion, to the extent practicable, of areas that are particularly susceptible to erosion and sediment loss;
2. Preserve areas that provide important water quality benefits and/or are necessary to maintain riparian and aquatic biota; and
3. Site development, including roads, highways, and bridges, to protect to the extent practicable the natural integrity of waterbodies and natural drainage systems.

To accomplish the goals of this measure, the partners of the FCT will utilize several strategies to protect critical areas to maintain water quality in Old Woman Creek and work with local communities to guide development in a way that is ecologically and economically sustainable.

Riparian and Wetland Setbacks

The adoption and use of riparian and wetland setbacks will be developed by reviewing the applicability of existing models for use by the local communities. The setbacks will be based on drainage area, with a minimum size of 25 feet, but may also be expanded to include areas of highly erodible soil, steepness of slope, and floodplain width.

Critical Area Protection

Priority areas of conservation have been identified in OWC NERR Conservation Strategy, which include areas surrounding the Reserve boundary and the entire riparian corridor. Vernal pools areas, which have not be specifically identified within the document are also of interest for conservation. The FCT partners, including the Western Reserve land Conservancy, OWC NERR, Erie SWCD and Huron SWCD, will develop land conservation options which may include easements or acquisition of areas identified as critical to maintaining water quality in Old Woman Creek.

Watershed-based Comprehensive Planning

The FCT partners will assist in the to creation of a comprehensive plan based on a watershed scale which will utilized the principles established in the Ohio Balanced Growth Program. The comprehensive plan will center future development on the existing resources of the Berlin Heights area which will allow for preservation of both cultural and natural heritage unique to the watershed.

Primary Objectives

- Adoption of riparian and wetland setbacks
- Watershed-based comprehensive plan
- Land conservation through easements and land acquisition

Site Development. The goal of this management measure is to reduce the generation of nonpoint source pollution and to mitigate the impacts of urban runoff and associated pollutants from all site development, including activities associated with roads, highways, and bridges. Management Measure II.C is intended to provide guidance for controlling nonpoint source pollution through the proper design and development of individual sites. This management measure differs from Management Measure II.A, which applies to post-development runoff, in that Management Measure II.C is intended to provide controls and policies that are to be applied during the site planning and review process. These controls and policies are necessary to ensure that development occurs so that nonpoint source concerns are incorporated during the site selection and the project design and review phases. While the goals of the Watershed Protection Management Measure (II.B) are similar, Management Measure II.C is intended to apply to individual sites rather than watershed basins or regional drainage basins. The goals of both the Site Development and Watershed Protection Management Measures are, however, intended to be complementary and the measures should be used within a comprehensive framework to reduce nonpoint source pollution.

Plan, design, and develop sites to:

1. Protect areas that provide important water quality benefits and/or are particularly susceptible to erosion and sediment loss;
2. Limit increases of impervious areas, except where necessary;
3. Limit land disturbance activities such as clearing and grading, and cut and fill to reduce erosion and sediment loss; and
4. Limit disturbance of natural drainage features and vegetation.

As stated in the New Development Management Measure, the Erie County stormwater regulations for pre and post-construction stormwater management have been revised to include measures to maintain and improve water quality of developed sites where applicable. This document stresses preserving the use of natural hydrology in the stormwater design, maintaining or improving hydrology as not to negatively impact the receiving waters, and utilize structural and non-structural BMPs for reducing erosion and sedimentation that may result from the development. These regulations currently cover unincorporated areas of the county which include much of the Old Woman Creek watershed. The regulations do not cover the areas of the watershed within the Village of Berlin Heights or Huron County. Adoption of these regulations or similar documents by the unregulated communities would fully address this management measure within the watershed.

In addition to the updated stormwater regulations, site plan reviews conducted by the SWCD will provide better assessment of potential environmental impacts of a proposed development. Technical expertise of the SWCDs will provide local communities insight to additional governing regulatory considerations developed through state and federal programs and provide alternative stormwater techniques to reduce run-off pollution potential of the finished development. SWCDs will need to

formalize technical assistance agreements with local communities and or the governing agencies for the site plan review process.

Primary Objective

- Site plans review process to include environmental considerations (wetlands, riparian corridors, TMDL reports, etc.)

Existing Development Management. The purpose of this management measure is to protect or improve surface water quality by the development and implementation of watershed management programs that pursue the following objectives:

1. Reduce surface water runoff pollution loadings from areas where development has already occurred;
2. Limit surface water runoff volumes in order to minimize sediment loadings resulting from the erosion of streambanks and other natural conveyance systems; and
3. Preserve, enhance, or establish buffers that provide water quality benefits along waterbodies and their tributaries.

The Berlin Heights sub-basin of the Old Woman Creek watershed currently has the highest amount of impervious surface of the 5 sub-basins. Installation of stormwater BMP retrofits within the Berlin Heights sub-basin would best concentrate efforts to reduce negative impacts affecting the creek. Opportunities for such retrofits need to be identified within the community and implemented with the purpose to reduce potential run-off impacts and increase individual stewardship of the creek.

In conjunction to reducing stormwater related impacts within the urbanized area of the watershed, the FCT partners will seek out individual partnerships with local landowners to increase the preservation and enhancement of the creek's natural corridor. Natural corridors provide many essential benefits to the integrity of the stream: flood storage, pollutant assimilation, and habitat. Approximately 43% percent of the stream corridor (150 feet each side) contains woody vegetation. To increase the amount of natural woody corridor of the creek, the FCT seeks to promote a Riparian Buffer Restoration Program within the east branch. Initial focus of the program will be to connect existing corridors on the east branch based on landowner interest.

Primary Objectives

- Identify opportunities and develop cost/benefit report for stormwater retrofits possible within the Berlin Heights area.
- Riparian Buffer Restoration Program

New On-Site Disposal Systems (OSDS). The purpose of this management measure is to protect the Coastal Zone management area from pollutants discharged by OSDS. The measure requires that OSDS be sited, designed, and installed so that impacts to waterbodies will be reduced, to the extent practicable.

Factors such as soil type, soil depth, depth to water table, rate of sea level rise, and topography must be considered in siting and installing conventional OSDS.

1. Ensure that new Onsite Disposal Systems (OSDS) are located, designed, installed, operated, inspected, and maintained to prevent the discharge of pollutants to the surface of the ground and to the extent practicable reduce the discharge of pollutants into ground waters that are closely hydrologically connected to surface waters. Where necessary to meet these objectives: (a) discourage the installation of garbage disposals to reduce hydraulic and nutrient loadings; and (b) where low-volume plumbing fixtures have not been installed in new developments or redevelopments, reduce total hydraulic loadings to the OSDS by 25 percent. Implement OSDS inspection schedules for preconstruction, construction, and postconstruction.
2. Direct placement of OSDS away from unsuitable areas. Where OSDS placement in unsuitable areas is not practicable, ensure that the OSDS is designed or sited at a density so as not to adversely affect surface waters or ground water that is closely hydrologically connected to surface water. Unsuitable areas include, but are not limited to, areas with poorly or excessively drained soils; areas with shallow water tables or areas with high seasonal water tables; areas overlaying fractured bedrock that drain directly to ground water; areas within floodplains; or areas where nutrient and/or pathogen concentrations in the effluent cannot be sufficiently treated or reduced before the effluent reaches sensitive waterbodies;
3. Establish protective setbacks from surface waters, wetlands, and floodplains for conventional as well as alternative OSDS. The lateral setbacks should be based on soil type, slope, hydrologic factors, and type of OSDS. Where uniform protective setbacks cannot be achieved, site development with OSDS so as not to adversely affect waterbodies and/or contribute to a public health nuisance;
4. Establish protective separation distances between OSDS system components and groundwater which is closely hydrologically connected to surface waters. The separation distances should be based on soil type, distance to ground water, hydrologic factors, and type of OSDS;
5. Where conditions indicate that nitrogen-limited surface waters may be adversely affected by excess nitrogen loadings from ground water, require the installation of OSDS that reduce total nitrogen loadings by 50 percent to ground water that is closely hydrologically connected to surface water.

Currently the Erie County General Health District follows more stringent rules for reviewing and approving the installation of new Home Sewage Treatment Systems (HSTS) (Chapter 29-01 thru 29-17, adopted June 26th, 2007, revised July 31st, 2007 and December 11th, 2007). These new rules establish criteria for prohibiting systems in environmentally sensitive areas such as setbacks from surface waters, protective separation distances from HSTS system components and groundwater, etc. However, the Berlin Heights area is unique in landscape, population density,

and soil conditions suggesting that addition, replacement, or upgrading of HSTS may not serve as the most acceptable way to treat wastewater while allowing the village to grow. Instead, alternative centralized wastewater treatment needs to be explored.

Primary Objectives

- Revise current HSTS regulations to include wetland setback provision
- Complete cost/benefit analysis for improved wastewater treatment of the Berlin Heights area
- Develop wastewater treatment improvement plan for the Berlin Heights area

Operating On-Site Disposal Systems. The purpose of this management measure is to minimize pollutant loadings from operating OSDS. This management measure requires that OSDS be modified, operated, repaired, and maintained to reduce nutrient and pathogen loadings in order to protect and enhance surface waters. In the past, it has been a common practice to site conventional OSDS in coastal areas that have inadequate separation distances to ground water, fractured bedrock, sandy soils, or other conditions that prevent or do not allow adequate treatment of OSDS-generated pollutants. Eutrophication in surface waters has also been attributed to the low nitrogen reductions provided by conventional OSDS designs.

1. Establish and implement policies and systems to ensure that existing OSDS are operated and maintained to prevent the discharge of pollutants to the surface of the ground and to the extent practicable reduce the discharge of pollutants into ground waters that are closely hydrologically connected to surface waters. Where necessary to meet these objectives, encourage the reduced use of garbage disposals, encourage the use of low-volume plumbing fixtures, and reduce total phosphorus loadings to the OSDS by 15 percent (if the use of low-level phosphate detergents has not been required or widely adopted by OSDS users). Establish and implement policies that require an OSDS to be repaired, replaced, or modified where the OSDS fails, or threatens or impairs surface waters;
2. Inspect OSDS at a frequency adequate to ascertain whether OSDS are failing;
3. Consider replacing or upgrading OSDS to treat influent so that total nitrogen loadings in the effluent are reduced by 50 percent. This provision applies only:
 - o where conditions indicate that nitrogen-limited surface waters may be adversely affected by significant ground water nitrogen loadings from OSDS, and
 - o where nitrogen loadings from OSDS are delivered to ground water that is closely hydrologically connected to surface water.

The Erie County Health District currently has the authority to initiate an Operations and Maintenance Program that requires residents to have a service contract for operating and maintaining their system properly. However, the ECHD does not have a central digital database of existing systems in Erie County which has halted the progress of this program. Most inspection of presumed failing HSTS is by complaint or in response to several consistent water contamination advisories obtained from the beach monitoring program. Creation of this database would streamline the review process of maintenance and performance of existing systems and reduce costly source investigation.

Primary Objectives

- Complete central database of HSTS in the Erie County area
- Initiate Erie County Health District Operations and Maintenance Program as defined in Chapter 29 -15.1 of the Home Sewage Treatment System Rules.
- Develop an education campaign for proper maintenance of HSTS and use of low-flow plumbing fixtures to reduce discharge of pollutants

Planning, Siting and Developing Roads and Highways (Local Only).

The best time to address control of NPS pollution from roads and highways is during the initial planning and design phase. New roads and highways should be located with consideration of natural drainage patterns and planned to avoid encroachment on surface waters and wet areas. Where this is not possible, appropriate controls will be needed to minimize the impacts of NPS runoff on surface waters.

Plan, site, and develop roads and highways to:

1. Protect areas that provide important water quality benefits or are particularly susceptible to erosion or sediment loss;
2. Limit land disturbance such as clearing and grading and cut and fill to reduce erosion and sediment loss; and
3. Limit disturbance of natural drainage features and vegetation.

Bridges (Local Only). This measure requires that NPS runoff impacts on surface waters from bridge decks be assessed and that appropriate management and treatment be employed to protect critical habitats, wetlands, fisheries, shellfish beds, and domestic water supplies. The siting of bridges should be a coordinated effort among the States, the FHWA, the U.S. Coast Guard, and the Army Corps of Engineers. Locating bridges in coastal areas can cause significant erosion and sedimentation, resulting in the loss of wetlands and riparian areas. Additionally, since bridge pavements are extensions of the connecting highway, runoff waters from bridge decks also deliver loadings of heavy metals, hydrocarbons, toxic substances, and deicing chemicals to surface waters as a result of discharge through scupper drains with no overland buffering. Bridge maintenance can also

contribute heavy loads of lead, rust particles, paint, abrasive, solvents, and cleaners into surface waters. Protection against possible pollutant overloads can be afforded by minimizing the use of scuppers on bridges traversing very sensitive waters and conveying deck drainage to land for treatment. Whenever practical, bridge structures should be located to avoid crossing over sensitive fisheries and shellfish-harvesting areas to prevent washing polluted runoff through scuppers into the waters below. Also, bridge design should account for potential scour and erosion, which may affect shellfish beds and bottom sediments.

Site, design, and maintain bridge structures so that sensitive and valuable aquatic ecosystems and areas providing important water quality benefits are protected from adverse effects.

There are no planned bridge projects occurring within the Old Woman Creek watershed in the next 5 years.

Operation and Maintenance of Roads, Highways and Bridges.

Incorporate pollution prevention procedures into the operation and maintenance of roads, highways, and bridges to reduce pollutant loadings to surface waters. Substantial amounts of eroded material and other pollutants can be generated by operation and maintenance procedures for roads, highways, and bridges, and from sparsely vegetated areas, cracked pavements, potholes, and poorly operating urban runoff control structures. This measure is intended to ensure that pollutant loadings from roads, highways, and bridges are minimized by the development and implementation of a program and associated practices to ensure that sediment and toxic substance loadings from operation and maintenance activities do not impair coastal surface waters. The program to be developed, using the practices described in this management measure, should consist of and identify standard operating procedures for nutrient and pesticide management, road salt use minimization, and maintenance guidelines (e.g., capture and contain paint chips and other particulates from bridge maintenance operations, resurfacing, and pothole repairs). Incorporate pollution prevention procedures into the operation and maintenance of roads, highways, and bridges to reduce pollutant loadings to surface waters.

Maintenance of transportation corridors within the Old Woman Creek watershed is performed by the either ODOT, the County, or local township. These agencies, particularly ODOT and the County Engineer, must follow good housekeeping measures for reducing nonpoint pollution in relation to general maintenance of the roads as part of their NPDES Phase II permit obligations. To expand the best management measures of roadway maintenance to include township roads, the FCT partners will assist the local townships in reviewing current operation standards and methods and provide suggestions for improving good housekeeping practices to reduce water pollution.

In addition to improving good housekeeping practices, the FCT will also develop an Emergency spill response plan for the watershed. Old Woman Creek has several major transportation corridors transecting the watershed used to transport

hazardous materials. The FCT partners plan to expand the initial hazardous response plan that was developed for the Reserve and expanding it to include the entire watershed. In conjunction to the plan, countermeasures such as a spill control boom, will be placed at strategic bridge crossings to contain hazardous materials that could negatively impact the creek from the result of an accidental spill.

Primary Objectives

- Review current transportation corridor maintenance operation practices performed by local townships within the watershed
- Develop Emergency Spill Response Plan for the entire watershed

Runoff Systems for Roads, Highways, and Bridges. Develop and implement runoff management systems for existing roads, highways, and bridges to reduce runoff pollutant concentrations and volumes entering surface waters.

This measure requires that operation and maintenance systems include the development of retrofit projects, where needed, to collect NPS pollutant loadings from existing, reconstructed, and rehabilitated roads, highways, and bridges. Poorly designed or maintained roads and bridges can generate significant erosion and pollution loads containing heavy metals, hydrocarbons, sediment, and debris that run off into and threaten the quality of surface waters and their tributaries. In areas where such adverse impacts to surface waters can be attributed to adjacent roads or bridges, retrofit management projects to protect these waters may be needed (e.g., installation of structural or nonstructural pollution controls). Retrofit projects can be located in existing rights-of-way, within interchange loops, or on adjacent land areas. Areas with severe erosion and pollution runoff problems may require relocation or reconstruction to mitigate these impacts. Runoff management systems are a combination of nonstructural and structural practices selected to reduce nonpoint source loadings from roads, highways, and bridges. These systems are expected to include structural improvements to existing runoff control structures for water quality purposes; construction of new runoff control devices, where necessary to protect water quality; and scheduled operation and maintenance activities for these runoff control practices. Typical runoff controls for roads, highways, and bridges include vegetated filter strips, grassed swales, detention basins, constructed wetlands, and infiltration trenches.

1. Identify priority and watershed pollutant reduction opportunities (e.g., improvements to existing urban runoff control structures; and
2. Establish schedules for implementing appropriate controls.

Although most pollutant loading occurring in Old Woman Creek is a result of agricultural run-off, there are several bridge crossings where concentrated flows have eroded the streambank. The FCT partners will categorize these areas where stormwater improvements will protect the bank and reduce sediment loading to the creek and develop associated costs for implementing various control features.

Primary Objectives

- Identify opportunities and develop cost/benefits analysis report for stormwater retrofits for inter/intrastate transportation infrastructure transecting the watershed for the purpose of reducing run-off related pollution

Channelization and Channel Modification (Physical and Chemical Characteristics of Surface Waters). The purpose of this management measure is to ensure that the planning process for new hydromodification projects addresses changes to physical and chemical characteristics of surface waters that may occur as a result of the proposed work. Implementation of this management measure is intended to occur concurrently with the implementation of Management Measure B (In-stream and Riparian Habitat Restoration) of this section. For existing projects, the purpose of this management measure is to ensure that the operation and maintenance program uses any opportunities available to improve the physical and chemical characteristics of the surface waters. Changes created by channelization and channel modification activities are problematic if they unexpectedly alter environmental parameters to levels outside normal or desired ranges. The physical and chemical characteristics of surface waters that may be influenced by channelization and channel modification include sediment, turbidity, salinity, temperature, nutrients, dissolved oxygen, oxygen demand, and contaminants.

Implementation of this management measure in the planning process for new projects will require a two-pronged approach:

1. Evaluate, with numerical models for some situations, the types of NPS pollution related to in-stream changes and watershed development.
2. Address some types of NPS problems stemming from in-stream changes or watershed development with a combination of nonstructural and structural practices.

Channelization and Channel Modification (In-stream and Riparian Habitat Restoration). The purpose of this management measure is to correct or prevent detrimental changes to in-stream and riparian habitat from the impacts of channelization and channel modification projects. Implementation of this management measure is intended to occur concurrently with the implementation of Management Measure A (Physical and Chemical Characteristics of Surface Waters) of this section.

Contact between floodwaters and overbank soil and vegetation can be increased by a combination of setback levees and use of compound-channel designs. Levees set back away from the streambank (setback levees) can be constructed to allow for overbank flooding, which provides surface water contact to important streamside areas (including wetlands and riparian areas). Additionally, setback levees still function to protect adjacent property from flood damage. Compound-channel

designs consist of an incised, narrow channel to carry surface water during low (base)-flow periods, a staged overbank area into which the flow can expand during design flow events, and an extended overbank area, sometimes with meanders, for high-flow events. Planting of the extended overbank with suitable vegetation completes the design.

Preservation of ecosystem benefits can be achieved by site-specific design to obtain predefined optimum or existing ranges of physical environmental conditions. Mathematical models can be used to assist in site-specific design. In-stream and riparian habitat alterations caused by secondary effects can be evaluated by the use of models and other decision aids in the design process of a channelization and channel modification activity. After using models to evaluate secondary effects, restoration programs can be established.

There is only one day-lighted ditch currently under maintenance in the Old Woman Creek watershed. Future ditch maintenance projects petitioned through the SWCD or county engineer will be conducted in collaboration with the appropriate committee's of the FCT to provide technical assistance to protect the water quality of the watershed.

Additionally, the FCT Tribes Team volunteer monitoring program will provide valuable water quality data of various locations within the watershed that may serve as baseline water quality standard to monitor project impacts.

Primary Objectives

- Riparian and wetland enhancement
- Complete one demonstration project for natural channel design
- Watershed monitoring program

Eroding Streambanks and Shorelines. Several streambank and shoreline stabilization techniques will be effective in controlling coastal erosion wherever it is a source of nonpoint pollution. Techniques involving marsh creation and vegetative bank stabilization ("soil bioengineering") will usually be effective at sites with limited exposure to strong currents or wind-generated waves. In other cases, the use of engineering approaches, including beach nourishment or coastal structures, may need to be considered. In addition to controlling those sources of sediment input to surface waters which are causing NPS pollution, these techniques can halt the destruction of wetlands and riparian areas located along the shorelines of surface waters. Once these features are protected, they can serve as a filter for surface water runoff from upland areas, or as a sink for nutrients, contaminants, or sediment already present as NPS pollution in surface waters

As listed in Chapter 7, there are several areas in need of streambank stabilization. Changes in hydrologic patterns and channel morphology have subsequently altered

downstream portion of the watershed particularly in the Till Plains region. These alterations combined with higher gradient and highly erodible soils make stabilization of stream banks in this area a two-tailed process of reducing the shear force of the stream on the bank and improving vegetation to increase the tensile strength of the bank.

The FCT will seek financial assistance to stabilize and eroding bank by utilizing natural channel design. The use of natural channel design allows greater interface between water and vegetation which helps filter out pollutants and disperse high energy of peak flows as well as reduce streambank erosion.

Primary Objectives

- Riparian Buffer Restoration Program
- Watertable management program to restore natural flow regimes in watershed

Table 49: Summary of implementation strategies associated with the Coastal Nonpoint Pollution Control Program Management Measures.

| Strategies | Coastal Non-Point Pollution Control Program Management Measure | | | | | | | | | | | Implementation | | | | |
|---|--|----------------------|------------------|----------------------|-----------------------------|------------------------------------|---|---------|---|--|---|---|-----------|------------------|-----------------------------|-------------------------|
| | New Development | Watershed Protection | Site Development | Existing Development | New On-Site Disposal System | Operating On-Site Disposal Systems | Planning, Siting, Developing Roads and Highways | Bridges | Operation and Maintenance of Roads, Highways, and Bridges | Run-off Systems for Roads, Highways, and Bridges | Channelization and Channel Modification (Physical and Chemical Characteristics of Surface Waters) | Channelization and Channel Modification (Instream and Riparian Habitat) | Timeline | Cost (estimates) | Reference WAP Chapter 6 & 7 | Lead Agencies |
| Upgraded Stormwater Regulations for Erie County | X | | X | | | | X | | | | | | completed | n/a | | Erie Co. Engineer |
| Adoption of upgraded Erie County Stormwater Regulations (or similar regulations) by Village of Berlin Heights and Huron County | X | | | | | | X | X | | | | | 2012 | n/a | | Huron Co. Engineer BHVC |
| Education of importance of stormwater management for future adoption of existing regulations and enhancement of current policies provided to Huron County and Village of Berlin Heights | X | | | | | | X | X | | | | | ongoing | \$18,425 | √ | ESWCD OCTP |
| Collaboration of watershed approach related stormwater trainings and notification to local officials and appropriate agency staff. | X | | | | | | X | X | | | | | ongoing | n/a | | ESWCD |

| | | | | | | | | | | | | | | | | |
|--|--|---|---|---|---|---|---|---|---|---|--|--|------------------------------|---------------|---|---------------------------|
| Site plan reviews to include environmental considerations (wetlands, riparian corridors, TMDL reports, etc.) | | X | | | | | | | | | | | 2010-ongoing | \$10,000 | | Erie Co. Engineer |
| Adoption of Riparian and Wetland Setback Regulations | | X | X | | | | X | X | | | | | 2010-2012 | \$8,195 | √ | Townships BHVC |
| Comprehensive planning for the Berlin Heights area utilizing Balanced Growth Principals | | X | X | X | | | X | X | | | | | 2011-2014 | \$12,210 | √ | BHVC ERPC |
| Land conservation through easements and land acquisition utilizing areas outlined in the Old Woman Creek Conservation Strategy | | X | X | X | | | | | | | | | Dependent on willing sellers | Site specific | √ | WRLC ESWCD HSWCD |
| Identify opportunities and develop cost/benefit report for stormwater retrofits possible within the Berlin Heights area. | | | | | X | | | | | | | | 2012-2014 | \$10,000 | | ESWCD |
| Promote Riparian Buffer Restoration Program | | | | X | | | | | X | X | | | 2012-2013 | \$76,315 | √ | ESWCD HSWCD |
| Revise current HSTS regulations to include wetland setback provision | | | | | X | | | | | | | | 2010 | n/a | | EGHD |
| Complete cost/benefit analysis for improved wastewater of the Berlin Heights area | | | | | X | | | | | | | | 2009 | \$20,997 | √ | EGHD |
| Develop a wastewater treatment improvement plan for the Berlin Heights area | | | | | X | | | | | | | | 2011-2012 | \$25,905 | √ | BHVC ERPC |
| Complete central database of HSTS in the Erie County area | | | | | X | X | | | | | | | 2009-2010 | \$10,000 | | EGHD |
| Initiate Erie County Health District Operations and Maintenance Program for existing HSTS | | | | | X | X | | | | | | | 2011 | n/a | | EGHD |
| Develop education campaign for proper maintenance of HSTS and use of low-flow plumbing fixtures | | | | | X | X | | | | | | | 2010-2014 | \$15,000 | | ESWCD EGHD OWC NERR |

Chapter 9. Evaluation and Revision

EVALUATION

The primary goal of the Old Woman Creek Watershed Action Plan is to improve stream segments that are not meeting attainment status as defined by the Ohio EPA and enhance the ecological integrity of the creek, estuary, and barrier beach. The FCT partners realize that accomplishment of these goals depends not only on the use of conservation practices such as BMPs but also on the engagement and development of a sense of ownership among people living in and near the watershed. Evaluation of this plan will address both of these factors: water quality and community engagement.

Water Quality

The evaluation of pollutant reduction will depend partly on monitoring the stream before and after specific projects, monthly monitoring of the entire watershed, and intensive monitoring of the estuary. Using different scales of monitoring will aid in the evaluation of each strategy's impact both remotely and at the watershed level. Near shore monitoring of the estuary provides an understanding of the wetland's role in filtering pollutants before they reach Lake Erie and how climate affects the flow and relative loading rates of pollutants from storms. Monitoring will be performed as previously described by the Tribes Team volunteers and OWC NERR SWMP. The Monitoring Committee will provide oversight for data related to water quality improvements resulting from the FCT efforts and will provide recommendations to the plan strategies as needed to improve implementation.

Community Engagement

As previously described, the participation of the local community is essential in the lasting success of water quality improvement projects. The FCT plans to utilize its partners to continue the education and outreach efforts of watershed stewardship within surrounding communities. Evaluation of education and outreach efforts will be accomplished through the use of the Soil and Water Information Management System (SWIMS). This system documents events and materials along with attendance and additional comments on the impact of the activity. The Education Committee will establish goals and conduct program evaluation.

REVIEW AND REVISION

An internal review of plan strategies completed will be completed each year. This review will be conducted by the FCT coordinator and the Advisory Board. Successes and challenges will be discussed and the watershed action plan implementation timeline adjusted accordingly. After the yearly review, a report will be presented to the FCT partners at the next partners' lunch and will be included in the subsequent newsletter. An update for the plan will be initiated by the Advisory Board after five years, unless otherwise stated by the Board. As in the initial planning process, residents, business owners, civic groups, public officials, and agency staff will participate in the revision process.

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**Appendix A. Erie SWCD and Friends of OWC
Memorandum of Understanding**

Memorandum of Understanding Between Friends of Old Woman Creek and Erie Soil and Water Conservation District

Purpose

Recognizing the need for effective collaboration in carrying out required responsibilities, related to the Firelands Coastal Tributaries Watershed Coordinator Program in the Firelands Region of north central Ohio, Friends of Old Woman Creek, hereafter referred to as the "Friends" and the Erie Soil and Water Conservation District, hereafter referred to as the "District" accept this Memorandum of Understanding, herein after referred to as "MOU" as the document that describes the process for exchange. Cooperation between these two entities facilitates the successful delivery of the program described in the grant documents as attached to this agreement as Exhibit "A". The Ohio Revised Code, Ch 1515, describes the District's authorities and responsibilities as a subdivision of the State of Ohio.

The activities performed will be in accordance with activities and deliverables outlined in the Firelands Coastal Tributaries Watershed Coordinator Grant Agreement as executed between Ohio Department of Natural Resources, Division of Soil and Water Conservation (ODNR DSWC) and Friends of Old Woman Creek on January 1, 2007, herein after referred to as "Grant Agreement".

Project Tasks

The District will work with the Friends, through the Advisory Board as established by the Grant Agreement, to establish, by mutual consent, a program to develop a successful, sustainable watershed program within the Old Woman Creek and Pipe Creek Watersheds. As the employer of the watershed coordinator position, the District will provide daily supervision, over-head, administrative and technical support, and fiscal reporting for the project.

In addition, the District will assist the Friends with facilitation and development of project partners and implementation of a state endorsed watershed action plan (WAP).

Grant Funds

Grant funds will be paid from ODNR DSWC to the Friends. The funds will be passed through to the District upon receipt from the DSWC. Funds will be used for salary, benefits and ancillary costs associated with the watershed coordinator position. The District will disburse the funds for eligible project costs as outlined within this MOU, the Grant Agreement, and any addendums hereto.

The District will provide information to the Friends for signature and reporting purposes required by the Grant Agreement.

District's Roles

The District will work with the Friends to provide the agreed upon services listed in Exhibit "A" and this MOU.

1. The District will provide the receipt, expenditure, and fiscal accounting of funds received through the grant agreement. Local match funds, provided by the Friends or direct from project partners, will also be properly accounted and reported for grant purposes.
2. The District will coordinate with the Friends, Advisory Board, and project partners to develop an annual work plan to accomplish project deliverables in a timely manner.
3. The District, in coordination with the Friends, will provide semi-annual technical, quarterly fiscal, and final reports as required by the Grant Agreement to describe all activities undertaken, and provide copies of all fliers, notices, and any data collected for reporting to state and local agencies and project partners.
4. The District will actively participate in identification and recruitment of additional project partners.
5. The District will provide technical services as required to achieve the deliverables of the grant.

Friends' Role

1. The Friends will coordinate with the District, Advisory Board, and project partners to provide input for the annual plan of work for the coordinator position.
2. The Friends will provide project information, including financial accounting, in a timely manner through channels identified in the annual work plan.
3. The Friends will provide assistance to the watershed project through related activities such as improvement days, education events, and other public involvement activities.
4. The Friends will assist with contacts and the provision of contact names, addresses and phone numbers of local leaders, including civic leaders, civic groups, senior organizations, fraternal groups, scout leaders, school liaisons, business leaders and any other interested parties that should be contacted through an outreach program.
5. The treasurer of the Friends will be bonded annually as required by the State of Ohio to manage the grant funds received.
6. Upon receipt, the grant funds will be paid to the District as outlined above.

Agreed Procedures

- That the working relationship will be defined to include lines of communications with appropriate representatives. The District and the Friends will meet at least once a year, outside the Advisory Board, to network and exchange information.
- That the Friends and the SWCD will meet when necessary to review and coordinate activities and programs with the aim of developing a multi-disciplinary approach to resource management.
- That all parties will review quality of service and address concerns as they arise.

- That credit will be given jointly to the SWCD, the Friends, and project partners in project publications.
- All services of the District are offered on a non-discriminatory basis without regard to race, age, marital status, handicap or political persuasion.
- The Friends recognize the District's obligation to make its reports and other written materials available to the public on request in accordance with the Ohio Public Records Act.
- The district shall prepare and provide required report information to the designated representative(s) of the Friends with reasonable time for review and approval prior to submission deadlines required by the Grant Agreement.
- Upon demonstration of concurrence through signature of designated representatives of the District and Friends, the required reports and documentation shall be submitted as required by the Grant Agreement.

This working agreement may be amended or terminated at any time by mutual consent of both parties, and the agreement may be terminated by either party giving sixty (60) days notice in writing to the other.

In witness thereof, the Memorandum executed and agreed to on the day, month and year written:

Erie Soil & Water
Conservation District

Friends of Old Woman Creek

By: Roger Rowland
Roger Rowland, Chair

By: Claire J. Waterfield

Date: 3 21 07

Date: 3-14-2007

Appendix B. Watershed Residents Survey

Old Woman Creek Watershed Resident Survey

Survey conducted: August-September 2007

Survey Implemented by: Breann Hohman, Watershed Coordinator

Purpose:

This survey was developed to serve as both a tool for outreach and means for gathering essential information about the local community's views and attitude about Old Woman Creek.

Method:

A two page survey was developed utilizing an existing survey created by Tim White, ESWCD and OSUE in 2002 for adjacent landowners of Mudbrook in Huron, OH. The original survey underwent a series of drafts based on suggestions provided by Heather Elmer, OWC NERR, and Tom Fish, Corporative Ecosystems Studies Unit Network. For increased convenience to the survey recipients, the survey was placed online using Survey Monkey and given the web address www.firelandtributaries.net.

A letter was initially sent out to approximately 834 watershed residents informing them of the upcoming survey and purpose of the watershed program. This mailing also provided a brochure of the Firelands Coastal Tributaries Watershed Program and invitation to the FCT Council meeting held August 14th, 2007.

The actual survey was sent out approximately one week later with an informative letter reiterating the survey's purpose and providing a web address to complete the survey online for convenience. A self-addressed envelope was also included if the resident preferred to return the survey via mail to ESWCD.

A reminder postcard was sent to all residents that had not already submitted a completed survey about two weeks after the initial survey mailing. For easy analysis, the hardcopy surveys received via mail were all entered into Survey Monkey using a volunteer of the FCT watershed program.

Results:

Total number of property owners in watershed: **895**

Total number of those property owners living within the watershed: **834**

Number of surveys presumed received: **759**

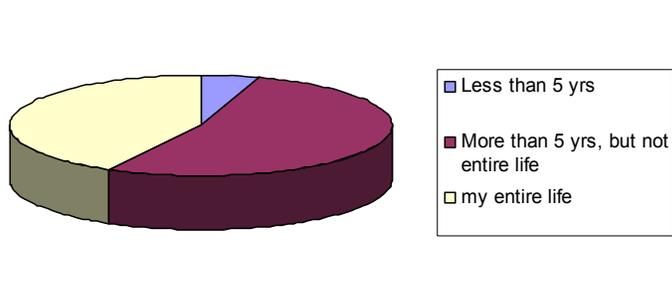
Number of surveys completed: **210**

Final sample size: **759**

Rate of response: **27.6%**

1. How long have you lived in the Old Woman Creek watershed?

| | |
|--------------------------------------|-----|
| More than 5yrs, less than whole life | 53% |
| My entire life | 42% |
| Less than five years | 5% |



2. What do you think about the overall quality of Old Woman Creek?

Fair to great 96%

3. This creek is best known to you for... (Top responses)

| | |
|-------------------------------|-----|
| Attracting birds and wildlife | 83% |
| Moving stormwater | 53% |
| Its Beauty | 46% |
| Its historical significance | 45% |

4. Residents were asked to score the following (Problem - 1 or not a problem-5)?

| Average Rating | |
|-------------------|-----|
| Odor | 4.5 |
| Eroding banks | 3.8 |
| Flooding | 3.8 |
| Water clarity | 3.7 |
| Trash/debris | 3.7 |
| Nuisance wildlife | 4.2 |
| Pollution | 3.8 |

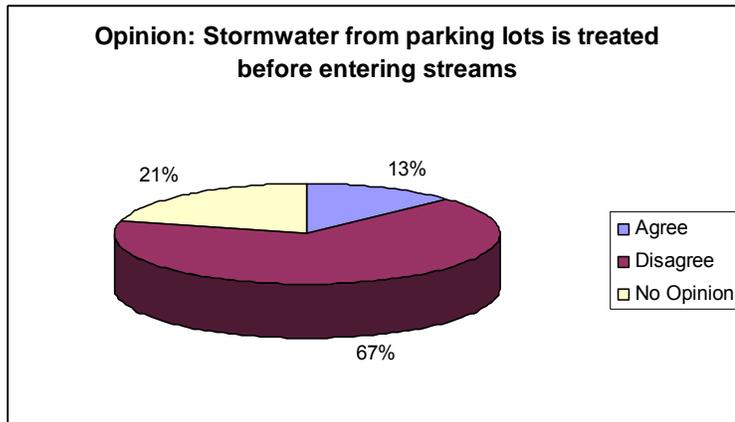
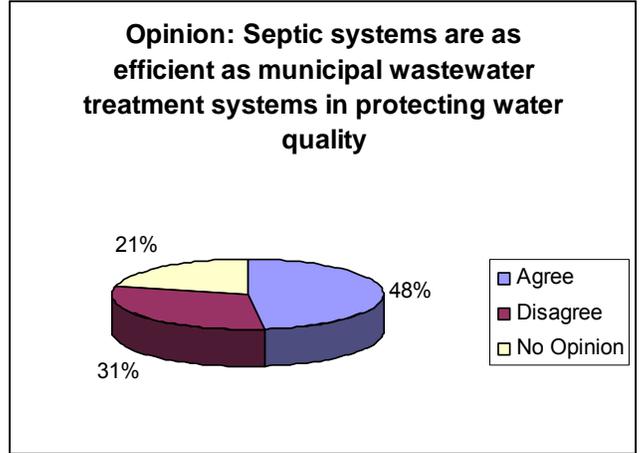
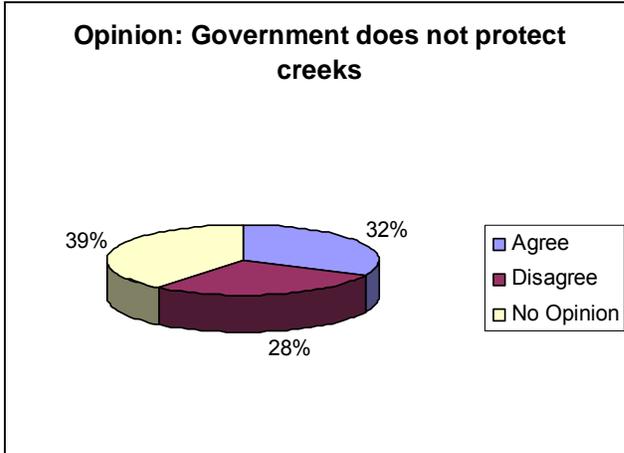
5. Residents were asked to give their opinions (Agree/Disagree/No opinion) on a series of questions relating to watershed stewardship, actions (or people) affect on the watershed, and individual actions pertaining to the watershed.

This series reflects basic understanding of what factors are needed to ensure the quality of the watershed is not negatively impacted; percent responses to these statements reflect agreement to the statement.

- 95%** Protecting small creeks is necessary to the "health" of larger rivers and Lake Erie.
- 81%** Improperly maintained construction sites are sources of water pollution.
- 68%** Placing dirt or other material along the side of a creek causes problems.
- 53%** Replacing small creeks with pipes is harmful to downstream areas.
- 94%** New developments should protect creeks.
- 68%** Disposing of grass cuttings and leaves in and along a creek hurts the creek's health.
- 80%** Leaving trees along a creek helps to keep a creek healthy.
- 97%** Creeks are an important area for wildlife.
- 89%** Our local creeks are a valuable nearby natural areas.
- 56% D** Placing crushed rock on stream banks is the only way to control erosion. ***

***This percent response is actually for disagreement

This series portrays the residents views government and infrastructure affecting the creek.

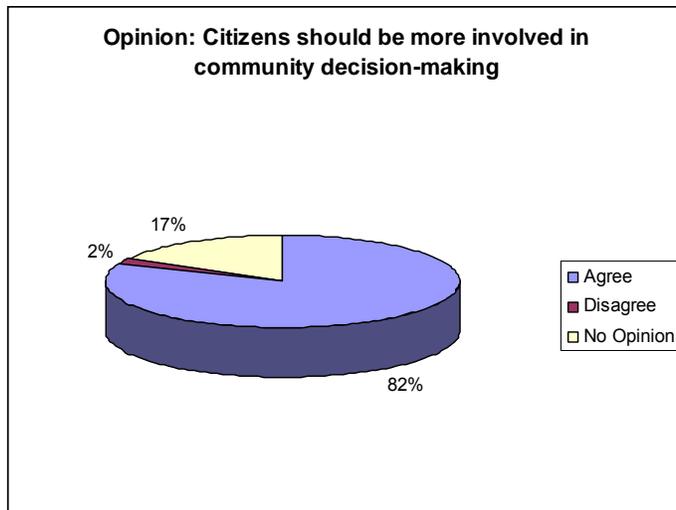
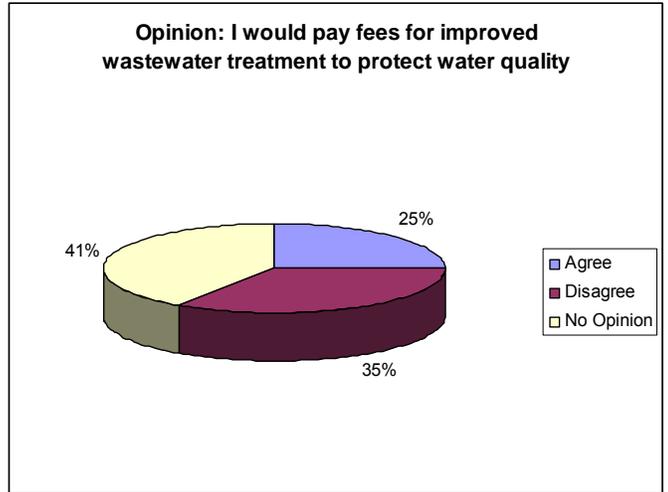
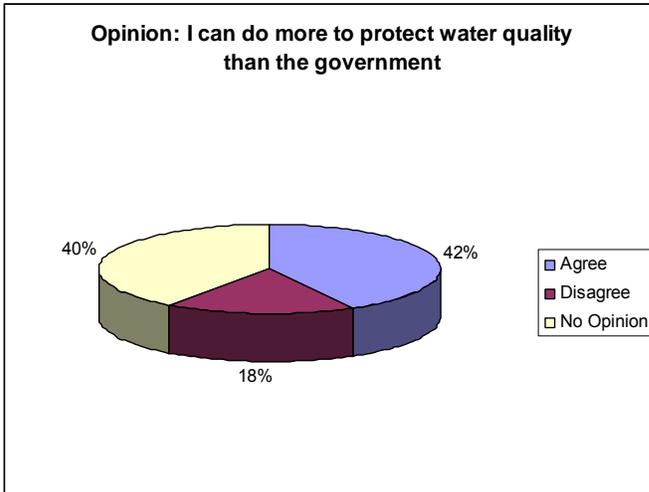


This series reflects the residents view of the creek in general.

88% Disagree I view our creek as a hazard.

46% No Opinion I would like the creek more if I knew what fish/animals were living in it.

This series identifies responsibility the residents feel they should have in improving their water quality.



6. Put the following land uses in order (1 = most harm to 6 = least harm) by which causes most harm to streams?

Most Harm



Least Harm

- Low density residential
- Roads and railroads
- Agriculture
- High density residential
- Commercial
- Industrial

8. How do you feel land use change (Farmland to Residential) affects water quality?

more residential takes away homes for wildlife, and that affects water quality
not much unless retention ponds are not built
farm land and low density residential will effect water quality, but with properly maintained septic systems and green barriers along farmland the impact can be minimized
Dont know
The fertilizer that is dispensed on farmland I think would be hazardous.
It hurts it a lot.
Depends on the application.
n/a
chemicals in h2o disturbed creek sides when it floods
Farmland would be best. Residential, even low level, causes littering and pollution to natural wildlife areas to a greater extent than farm and agriculture.
lowers quality
not sure
the chemicals the farmers use will wind up in our water
due to reduced use of pesticides and herbicides the water quality should improve with the change
depends on farm chemicals used
makes it better
disrupt natural ground filter systems
usual effect between
YES
unknown
Don't know but would guess and if residential properly setup/built/installed
harms water quality
open land absorbs run-off pavement doesn't. farmland better is ag chemicals kept in check
more people, more pollution
Both are important
Poorly maintained subdivisions and septic systems.
ok-provide run-off of herbicides and pesticides as controlled.
Improves it
1. Pesticides and fertilizers overused.

2. Fast run-off of rain water.
Badly
Decreases wildlife habitat, increases contamination.
It causes more nitrates, detergents, and chemicals to go into creeks and ditches.
Lowers the quality
All storm sewers going into creeks, also leech beds.
Improves it due to fertilizers, pesticides, ect. that farmers use.
More run-off
Sometimes
More pollution in the creek, by going through sewer systems,
Less nitrogen but more potential polluted run-off from housing salt from roads.
Residential areas increased water run-off
Yes
Oil/grease run-off covered areas
?Harmful?
More pollution in residential

Your problem would be a more controlled water with residential with no wells.
 The continuous land developments, and larger farm area with pesticides harm our water source.
 Possible decrease in pesticides and herbicides.
 We have enough residential properties that aren't selling! No need for more.
 All relative
 More pavement less water absorption/filtration more run-off
 Farmers care more about land and natural resources than city dwellers.
 for the better
 farms produce too much chemical run-off. Domestic use leads to poorly maintained leaching systems
 Blacktop doesn't hold much water-soil with plants does. Does this take a rocket scientist?
 Poorly
 makes it worse
 don't know enough to these questions.
 If managed correctly there should be no detrimental change.
 herbicides and pesticides that farmers use
 Less agt. run-off and sediment but more trash, road, and vehicle run-off.
 More people-more junk if people don't dispose of trash properly.
 More pollution
 Lawns that are sprayed for weeds run-off into creeks affects water.
 It doesn't have to affect water quality if proper safeguards are taken.
 Residential too much run-off of water too quickly, make water rise too quickly, flood problems.
 Residential has high impact
 Lawn chemicals weed control to fertilizers are way over used.
 Farmland and residential makes water quality much worse.
 No change to residential
 More trash and litter.
 More run-off of water.
 Farmland and low development is the best. Subdivisions and industrial cause the most harm.
 Both farm and residential need to be aware of chemical run-off. Do not spray land area near creeks.
 Little change
 Greatly causes pollution and flooding
 Not very much
 residential more harmful
 The problem with farmland is fertilizers run-off and erosion. Residential has very little fertilizer and plant growth to prevent erosion.
 I know farmland run-off is a hazard but residential sewage is much less desirable.
 Farmland, pesticides, residential-no opinion.
 Natural organisms live in soil also soil filters water building anything in nature's path affects it.
 any change will affect the balance of nature
 Dependent and many variables
 More run-off
 No opinion
 It hurts it
 People (like my neighbor) have a tendency to not want flooding of their land so they put in fill and restrict natural waterflow.
 Not sure
 When ever you have people living in an area the chances for pollution increase.
 More waste water from residential

Agree
 Adds more pollution-destroy natures resistance
 streets, driveways, and homes cover soil and take away surface area for water absorbtion, thus
 more run-off to creeks.
 Water quality gets worse
 Improves it
 unable to read
 It kills it
 Yes
 Depends on residential density and water treatment system.
 Decreases it
 Run-off
 More people, more waste and debrie.
 Reduces creeks health
 Not qualified to answer.
 It increases run-off which in turn increases flooding and erosion.
 It lowers water quality by causing more run-off and more pollution from lawn fertilizers,burying
 land yard waste,
 Detrimental
 It could have a big impact.
 With farmland you have more silt and and pesticide run-off with residential more solt and other
 chemicals, possibly sewage.
 It affects it negatively due to more sewage.
 Not sure if it does-if done properly.
 Run-off negative: agriculture residential:affects wildlife and debrie.
 usually upsets run-off
 It causes rain water to run-off faster causing stream banks to erode.
 Depends on how the farm land is used.
 Does more harm creates more chance for erosion and pollution.
 It adds to pollution run-off. Septic systems add pollution to water table.
 Decreases quality
 If done properly it does not have to have un desired affects.
 due to farmland less animals.plant habitate due to residential.
 Yes more run-off

9. Do you feel land use plans should be developed to protect our water and promote growth?

?
 Absolutely-too many businesses, residences cause pollution.
 Commercial and residential growth showed plans to protect water quality
 Could be
 definitely
 Definitely
 Definitely
 Definitely
 depends on what and why
 Forget about promoting growth.
 limit development
 Maybe-depends on who does it
 Mainly in development
 n/a
 Need green space & filter strips next to streams

No (7 Responses)
 No comment
 no opinion
 no opinion
 No, we have too much regulations now.
 No-each community has a zoning board that develops rules and regulations for land use.
 NOooooo!
 Not at the cost of tax payers
 Not sure
 Not sure
 Possibly, as long as possible.
 Protect the resources stop building useless residential areas.
 Protect the water and the growth. No need to let the corporation abandon property and take company out of the country.
 Protect the water but don't promote growth.
 Reduce pollutants and remove trash-yes Promote housing, smells, no.
 Regional planning commission
 Require area development not just frontage
 Somewhat
 to a limited degree
 To prevent sprawl, take a well planned slow growth mentality.....growth for \$\$\$\$ bad. Well Planned growthgood.
 To some degree
 Unsure
 we can do both
 Yes- these older farmers aren't going to be around to protect the crop acreage they love.
 Yes to some degree
 Yes!
 Yes!!
 Yes, a plan that would include all land in watershed, not just those next to creek.
 Yes, and lets split or storm and sanitary sewers to keep raw sewage out of the lake in storm conditions.
 Yes, I believe protection of our water and creek stay in place and should be enforced no matter who breaks it or how much money they have should be the priority before development starts.
 Yes, I wish, Berlin Heights townships would provide a sewer and water treatment facility.
 yes, long range planning is a great idea
 yes, promote what kind of growth?
 yes-certainly
 yesno
 yes (92 responses)

10. What, if anything, should be done to protect, manage, or enhance, Old Woman Creek and who should do it?

no opinion
 land owners should be stewards of their property along old woman creek keeping it clear of trash and debris
 wouldn't know
 No comment
 The State of Ohio should keep doing what they are doing to preserve Old Woman Creek.
 I don't know what is currently being done, so I cannot give opinion,
 n/a
 Keep it protected from industrial and residential pollution

don't know
joint effort with citizens and government
no opinion
expand the size of old woman's creek preserve. The wildlife division should do it.
Its fine now ODNR
Dept. of Env. Resource
Keep the government out and let the land owner take care of it themselves with proper planning.
Professional E.P.A. etc. should manage
Ideally, a co-operation effort between residents and government but education both as to the methods and outcomes most important.
Don't know
unknown
Dept. of Natural Resources and Core of Engineers
continue to be managed by an interested group
monitor and restrict run-off and sewage entering watershed state
I thought this was being done, that is why property taken and restrictions placed on livestock watering.
current program is good
Soil and Water should do it.
Preserve the natural flow and wildlife-ODNR
nothing
Controlled water run-off, farming too close to ditches, maintain flood planes, Erie Soil and Water District.
No opinion
Walk it in the winter and see all the Black Water; icicles that form off the cliffs and bluff
Everyone
Leave it alone
Keep testing it must be getting better.
State government should maintain
It is important to protect the creek But I am not sure the best way to do it.
Government and make the water cleaner.
Feds...useless! Local and state should have the power Buffer zone, wildlife area, minimal growth area. Less run-off fields with pipes to drain water into creek.
Does not need help
Nothing
Continue to monitor water quality-reinforce regulations-State.
?
Cut more trees: clean out creek
Have no idea
A committee with representatives from areas in the watershed. this should be provided from the ODNR.
Both land owners and governments
The county and property owners.
not much
seems a good job is already being done
Visit my property and I'll show you.
clean out bogs=trees and junk-trees-tires and rtc.
I'm, not sure what needs to be done. don't however do it locally. too much government runs up costs and down grades satisfaction.
Remove trees and debris that cause back up of the water and thus cause flooding up stream.
Property owners.

Encourage each property owner to clean up his own areas.

Sewage in all areas

don't know everyone in watershed

yearly inspectors

change farming practices along creek and golf courses(by government)

Maintain the wild; aspect-limit the amount and proximity of anything that would be or is a detriment.

Soil and Water

Just to be conscious of what development may due to the land and creek long term.

Stop pollution-erosion---state of Ohio waste authority--parks div. ---or Ohio university

Creek water run-off from lawns that spray for weeds.

Collaborative of public and private,

Keep close watch on residential of run-off

Something to control the flood better. Contractors should do work.

The county and community

Check and cleanup any raw sewage draining into the creek.

Continue the good work you are doing

Local and state agency working with local community. Feds. should only provide \$ or they will mess it up. (unable to read the writing or the rest of his opinion)

Educate the public

I should be checked and monitored by state of Ohio,

Government and local property owners.

I feel it is protected very well. All people should do what they can to help manage it.

Yes, the state and county and everyone.

1. keep area residents informed 2. area government with federal matching funds

I believe land management should be taught in school, most laws needed are already in place and should be enforced no matter who breaks it or how much it money they have.

It's banks should be policed for one thing; too much dumping. Who? EPA?

No opinion- at present time not well enough informed.

Public sewer, maybe? plus government.

It should be protected-the metro parks could manage and monitor with the money coming from the state and local taxes.

It should be protected and managed, but how or when??

State government should control the cost without more taxes.

Citizens

Keep government away from it.

Limit the number of residences.

Not sure

Everyone needs to make an effort and not to pollute the environment.

Reduce Ag. and home waste from creek ESWCD

No opinion

Introduced pollution should be stopped. enforce trash clean up by person who pays.

Property owners with help from government agencies should help clean up, share and maintain creek beds.

Should be protected from the wrong use/natural resources

I think the conservation is doing the best it can

Endorse standing law- federal law enforcement

I do not have enough information to determine what should be done. Citizen, local government and state government should do it.

Unknown

Co=operation of government and residents

Clean up trash, remove non-native species. Volunteers
unable to read
Keep tributaries open and work to maintain them so water, debris and trash don't continue to
build up.
Community and agencies
Good question, but feel present management seems to be doing a good job.
Declare a moratorium on building and increase the use of reduced or no tillage. Not the
government.
Protect against high density residential and industrial development.
No opinion
Programs in place like Lake Erie CREP should help, soil and water district needs to lead.
The county should protect, manage or enhance Old Woman Creek.
County-State-Federal
Not sure but more protection is needed.
ODNR-make more walking trail and make more access to the area.
Help land owners clear log jams to stop flooding.
Identify area that would impact water quality the most and educate those land owners.
stop building and place those efforts to stop pollution and erosion plant and trees and wild
flowers.
Impose fines to those who pollute. Educate all the public.
Regional planning commission
All septic tank drainage should be stopped.
The community/naturalists/environmentalists teach waste management, education programs and
activists for youths.
The steps that are being used are fine.

11. Have you witnessed dramatic changes in Old Woman Creek? If so, explain.

?

?

A good fishing stream was closed to public use unnecessary authority.
Appears more dirty with less water in it.
Damage due to development
Do not know
Have not been back there lately-would have to tour it.
Have not witnessed.
Horse farms and cattle farms in Berlin Heights probably is contributing to pollution in old
woman's creek. Some agency should investigate these areas.
I have not noticed.
I have reported junk being dumped on its banks to the health dept., EPA and Army Corps of
engineers and no one seems to think it's their problem. (west main street. Berlin Heights)
I swam in the creek as a kid but would hate to see my grand kids do so.
I think it is better since I was a kid 50 years ago.
I think it's cleaner than years ago, because of new septic tanks.
I used to play around it in the 60's I hardly look at now to notice any changes.
In the 70's used to fish and catch game fish. now you can't because of poor water quality.
It doesn't look as clean as it used to.
It gets deeper and wider every year. and carries more water.
It's much better in beauty in the last few years.
Just in the last 3 years major erosion.
Land development, farmers using chemicals
Like everywhere/human encroachment
Many fallen trees need to be cleaned up.

n/a

N/A

no (43 Responses)

no dramatic changes observed

No opinion Not that familiar with old woman's creek.

No, although the deeper pools are very slowly filling in.

No, I have lived here on and off for majority of my life.

No, I haven't been there in a while

No, I would like to see the fish south of the turnpike a barrier was placed and the fish could not continue south. There was a road placed across the creek which created a wall. The fish can not go beyond that.

No, not since the State has taken over.

No.

No-But I don't see the creek daily

no-I will not go to the creek any longer-too many rules and regulations-you have ruined it for me.

none

none

none seen

not really

Not really

Not really

One time agricultural run-off resulted in a die-off of aquatic life in my creek.

Only the increase of forestation on land that one time had been grassland.

Our creek is changing course piling up rocks and sand bars/

Seems to get better every year.

Some, water is cleaner and less soil run-off.

Still see salmon which is a good sign.

The odor along Rt. 2 as well as trash and debris has increased the past 3 years,

The flood of 1969 severely cleared things out.

unable to read

unknown

Water pollution

We never see the creek from our property. we enjoy adding trees and plants to our land thru the ESWCD spring plant sale.

We used to catch fish-now its all filled in

Yes, every new house has owners who discard wood and also ride dirt bikes through the low points.

yes, flooding, color, beach,

Yes, for the better, there is more no till which helps with erosion and the large land fills has stopped most of the trash and pollution out of the creek.

Yes, in my area the creek was rechannelled at Mason Rd. and fallen trees have caused some very serious bank erosion.

Yes, it seems like a well managed preserve that should be continually improved.

Yes, marshes have dramatically declined, water has a lot more sediment and minerals in it.

Yes, my woods that my creek runs through is flooding often. Tree species are dying(not just ash) some are scaly falling over from flooding that occurs outside of the main stream.

Yes-changes in flood control.

Yes-its better

I am 86yrs old as a boy during the depression I spent a lot of time at the creek not so much at the later years I don't know so much about it.

Yes-seen more wildlife attracted to the water.

12. I am interested in the following

Top Responses

| | |
|---|-----|
| Receiving a local newsletter about Old Woman Creek | 75% |
| Attending a local meeting about the creek | 48% |
| A workshop about evaluating the creek's health | 37% |
| A workshop on home sewage treatment system (septic) maintenance | 28% |
| A workshop about environmentally friendly lawn care and landscaping | 26% |

Additional Responses

| | |
|---|-----|
| Participate in a stream monitoring program | 21% |
| Joining the Friends of Old Woman Creek | 17% |
| Helping with a neighborhood creek clean up | 14% |
| Participate in a work group to enhance my watershed | 13% |
| Helping organize events or activities associated with Old Woman Creek | 7% |

Conclusions:

The views of the watershed itself reflected that of the socioeconomic characterization study; most felt connected to the watershed for environmental and historical reasons as well as for drainage. There was a high feeling that the watershed is in good condition with relatively few major issues affecting the quality of the stream. Of the issues listed by respondents, pollution, erosion, and water clarity are viewed to be the largest problems associated with the creek. There was a general feeling that land use change is mainly responsible for increased pollution in the watershed. However, responsibility for the restoration and protection of the watershed varied from the individual landowner up to Federal regulatory authority. Residents also felt they should be more involved with the community decision-making process. Additional comments made by respondents referring to changes in the watershed pointed to perceived restrictions on stream access and recreational activities. Many felt with the creation of the Reserve, fishing and hunting opportunities have been taken away from the local community.

Because of the basic understanding of land use and water pollution, educational strategies for increasing stewardship in OWC should provide instruction to stewardship techniques for the watershed such as septic system maintenance, natural landscaping, etc. One limitation found within the responses suggested that many residents' views were that of the reserve and not the entire watershed. It may be beneficial for the residents to understand the geographical extent of their watershed to develop a strong "watershed community". The strong feeling of importance and place OWC has for the community combined with negative impacts perceived land use change reflect opinions received from the focus groups. The variety of parties responsible parties for the creek suggest that watershed planning would be most effective involving both government and resident based engagement. Enhancing the recreational opportunities of OWC may also increase the level of ownership among residents.

Limitations

Small sample size, no accurate statistical analysis, no comparison studies.

Appendix A: Correspondence

PRE-LETTER

Greetings,

I am writing to ask for your help with a study of residents living in the Old Woman Creek watershed. This study is being conducted for the development of a watershed management plan for Old Woman Creek and is part of a larger effort conducted through the Firelands Coastal Tributaries (FCT) Watershed Program to learn about resident perceptions of Old Woman Creek.

Results from this survey will help us identify issues related to water quality in Old Woman Creek that need to be addressed. These results will be combined with other available data such as water quality studies to develop a community based Watershed Action Plan (WAP) to manage, protect, and enhance the integrity of the creek. Because this plan is community based, it is very important that you and other residents of the watershed have the chance to provide your views and goals for the future of Old Woman Creek.

In a few days, you will receive a letter and questionnaire that will provide you with instructions and more information about this project. You will also have the opportunity to complete the survey on-line.

If you do not receive a questionnaire within one week or have any questions about the survey, please contact me. We would greatly appreciate your input into this watershed program and look forward to your response.

Sincerely,

Breann Hohman, Coordinator
Firelands Coastal Tributaries Watershed Program

P.S. I have included a brochure about the FCT Watershed Program and invitation to FCT Council meeting August 14th at 7:00pm.

SURVEY COVER LETTER

Greetings,

I am writing to ask for your help with a survey of residents in the Old Woman Creek watershed. This study is part of a large effort conducted through the Firelands Coastal Tributaries Watershed Program to learn the local community's perception of the Creek.

Results from this survey will help us better understand your connections to Old Woman Creek and concerns related to water quality. Views from local community obtained through public meetings, surveys, and technical committees will be combined with other available data to develop a Watershed Action Plan (WAP) to manage, protect, and enhance the integrity of the Creek. This plan will be community based; so it is very important that you and other residents of the watershed are involved in the planning process.

Your answers are completely confidential and will be released only as summaries in which no individual's answers can be identified. If you chose to provide us with your contact information it will only be used to relay information about the FCT Watershed Program. This survey is voluntary. However, you can help us by taking a few minutes to respond to the enclosed survey or completing it online by visiting www.firelandstributaries.org. If for some reason you do not wish to respond, please let us know by sending back a blank survey with the self addressed envelope provided.

If you have any questions or comments, please do not hesitate to contact me at (419) 626-5211 or bhohman@erie-county-ohio.net.

Thank you very much for helping with this important study.

Sincerely,

Breann Hohman, Coordinator
Firelands Coastal Tributaries Watershed Program

WATERSHED SURVEY 2006

Do you live in the Old Woman Creek Watershed? (circle)

Yes No Don't know Other _____

What do you think about the overall quality of your creek?

Great 4 Fair 3 Terrible 1
5 4 3 2 1

Comments _____

This creek is best known to you for (check all that apply):

- ____ Recreation
- ____ Moving stormwater
- ____ Drinking water source
- ____ Its historical significance
- ____ Fishing
- ____ Attracting birds and other wildlife
- ____ Its beauty
- ____ Irrigation
- ____ Flood control
- ____ Other (explain) _____

Please score your creek on the following:

| | Not a problem | Problems exist | Major problem |
|-------------------|---------------|----------------|---------------|
| Odor | 5 | 4 | 2 |
| Eroding Banks | 5 | 4 | 2 |
| Flooding | 5 | 4 | 2 |
| Water Clarity | 5 | 4 | 2 |
| Trash/Debris | 5 | 4 | 2 |
| Nuisance Wildlife | 5 | 4 | 2 |
| Pollution | 5 | 4 | 2 |

Read the following statements associated with CREEKS, IN GENERAL, and circle your response:

| | | | |
|--|-------|------------|----------|
| Protecting small creeks is necessary to the "health" of larger rivers. | AGREE | NO OPINION | DISAGREE |
| Creeks are protected during development. | AGREE | NO OPINION | DISAGREE |
| Placing dirt or other material along the side of a creek causes problems. | AGREE | NO OPINION | DISAGREE |
| The government does not protect creeks. | AGREE | NO OPINION | DISAGREE |
| Replacing small creeks with pipes is harmful to downstream areas. | AGREE | NO OPINION | DISAGREE |
| New developments should protect creeks. | AGREE | NO OPINION | DISAGREE |
| Disposing grass cuttings and leaves in and along a creek hurts the creek's health. | AGREE | NO OPINION | DISAGREE |
| Stormwater from streets and parking lots need to be treated before entering streams. | AGREE | NO OPINION | DISAGREE |
| Leaving trees along a creek helps to keep a creek healthy. | AGREE | NO OPINION | DISAGREE |
| I can do more to protect creeks than the government. | AGREE | NO OPINION | DISAGREE |
| Creeks are an important area for wildlife. | AGREE | NO OPINION | DISAGREE |
| Our local creeks are a valuable nearby natural area. | AGREE | NO OPINION | DISAGREE |
| I view our creeks as a hazard. | AGREE | NO OPINION | DISAGREE |
| I would like the creeks more if I knew what fish/animals were living in them. | AGREE | NO OPINION | DISAGREE |
| The creeks would be better if the banks (sides) were made natural. | AGREE | NO OPINION | DISAGREE |
| I believe certain creeks have changed dramatically in the last few years. (explain) | AGREE | NO OPINION | DISAGREE |

I am interested in the following:

- A workshop about evaluating the creek's health.
- A workshop about lawn care and landscaping along the creeks.
- Receiving a local newsletter about up coming events.
- Joining a local creek protection group.
- Helping with a neighborhood creek clean up.
- Participate in a stream monitoring program.
- Attending a local meeting about the creek.
- Helping organize other events or activities associated with the creeks.
- Participate on a technical sub-committee
- Expertise _____

*PLEASE REMEMBER TO PROVIDE YOUR CONTACT INFORMATION

In your opinion, which does the most harm to creeks?

- | | |
|---|---------------------------------------|
| <input type="checkbox"/> Major Industry | <input type="checkbox"/> Government |
| <input type="checkbox"/> Private Landowners | <input type="checkbox"/> Farmers |
| <input type="checkbox"/> Small Business | <input type="checkbox"/> Construction |
| <input type="checkbox"/> Other _____ | |

In your opinion, which should be most responsible for protecting creeks?

- | | |
|---|---------------------------------------|
| <input type="checkbox"/> Major Industry | <input type="checkbox"/> Government |
| <input type="checkbox"/> Private Landowners | <input type="checkbox"/> Farmers |
| <input type="checkbox"/> Small Business | <input type="checkbox"/> Construction |
| <input type="checkbox"/> Other _____ | |

What, if anything, should be done to protect, manage, or enhance, our creeks?

Please provide your contact information in the space provided below.

Name _____

Organization* _____

Address _____

Phone _____

Email _____

*If resident only, please leave organization blank.

Thank you for participating; your opinions are greatly appreciated!



"We can not direct the wind, but we can adjust our sails"

-Unknown

Appendix F: Reminder postcard

ERIE SOIL AND WATER
CONSERVATION DISTRICT
2900 Columbus Ave
Sandusky, OH 44870

August 22, 2007

A couple of weeks ago, we sent you a questionnaire for an important watershed survey. If you have already returned the completed questionnaire or submitted it online, we thank you very much for your assistance.

If you have not yet had time to complete the questionnaire, please do so as soon as possible. Your participation is important for the success of this study. The survey will be available on-line at **www.firelandtributaries.net** through **September 7, 2007**.

If you have questions or need another copy of the questionnaire, please call (419) 626-5211 between 8:00 a.m. and 5:00 p.m. on weekdays or e-mail me at bhohman@erie-county-ohio.net

Appendix C. Public Meetings and OWC WAP Objectives Matrix

Old Woman Creek Watershed Planning Meetings

FCT Council

January 3, 2008

- Agenda
 - Introduction to the FCT program and watershed planning
 - Characterization of OWC
 - Presentation of current committee projects
- Participation
 - Discussion of water quality issues/challenges facing local streams in the FCT area
 - Discussion of possible resolutions/projects/tools to improve and protect the water resource
- Attendance
 - 36

July 2, 2008

- Agenda
 - Update on program progress
 - OWC WAP objectives matrix
 - Guest Speaker: Melinda Huntley (Ohio Sea Grant)
 - Grant updates
 - CMAG – Malfunctioning Home Sewage Treatment System Identification
 - GLC-Naturscaping in Erie County demonstration project
- Participation
 - Comments on educational displays for pollutant issues in OWC
 - Review of current objectives matrix for OWC WAP
- Attendance
 - 34

FCT Public Meetings

August 14, 2007

- Agenda
 - Introduction to the FCT and watershed planning in OWC
 - Characterization of OWC

- Participation
 - Discussion of reasons why attendees were present
 - Identification of potential roles of several agency representatives
- Attendance
 - 30

July 9, 2008

- Agenda
 - FCT program update
 - Grants updates
 - CMAG – Malfunctioning Home Sewage Treatment System Identification
 - GLC-Naturescaping in Erie County demonstration project
 - Presentation of OWC WAP objectives matrix
 - Overview of WAP development
- Participation
 - Discussion of items in objectives matrix
- Attendance
 - 12

September 17, 2008

- Agenda
 - FCT program update
 - Presentation of OWC WAP development and drivers behind problem statements
 - Presentation of two selected problem statements for discussion
- Participation
 - Question/Answer period for presented problem statements
 - Discussion of implementation of strategies
- Attendance
 - 15

October 8, 2008 (This presentation was at the Berlin Heights Village Council Meeting – geared for the residents of Berlin Heights)

- Agenda
 - FCT program update
 - Presentation of OWC WAP goals specifically in relation to the residents of Berlin Heights
 - Introduction of Roles of the BHVC in the implementation of the OWC WAP
- Participation
 - Question/Answer period for presented Items
- Attendance
 - 15

OWC WAP Objectives Matrix

This matrix was developed as a precursor to the document OWC WAP. Information used to develop this matrix was compiled from technical documents and the participation received by the public and active stakeholders. Technical documents utilized to develop this WAP aided in the identification of the water quality issues in the creek and helped to set appropriate goals for the WAP development. Public participation was used to identify social aspects of water quality and land use as well as identify areas for establishment of stewardship practices. Although much of the documents and notes used to develop this matrix are not fully presented in the WAP document, we feel the objectives matrix is a comprehensive summary of the information used to characterize the watershed and develop the strategies needed to improve the watershed community.

Old Woman Creek Watershed Action Plan and Firelands Coastal Tributaries Watershed Program Objectives

Mission: Increase watershed awareness and stewardship and reduce non-point source pollution entering our local streams.

| Goal | Objective | Action Items | Agency/Groups | Funds |
|--|--|---|--|-------------------------------|
| Reduce Sediment and Nutrient Loading in OWC (TMDL requirement) | <ul style="list-style-type: none"> Install over-wide channel demonstration site | <ul style="list-style-type: none"> Establish funding Mobilize time line Implement Project Project Demonstration event | ESWCD FOWC FPCW Monitoring Committee Stream adjacent property owners | GLC Great Lakes Basin Program |
| | <ul style="list-style-type: none"> Increase linear feet of buffer strips no less than 15ft in width within Till Plain sub basin | <ul style="list-style-type: none"> Identify critical areas in need of buffers Identify appropriate cost-share program Locate one-time incentive funding for sign-up Contact appropriate landowners Provide information session about buffers and cost-share Assist with implantation of buffers Identify demo sites for future tour of BMP successes Provide stream monitoring to evaluate buffer efficiency of reducing sediment loading | ESWCD NRCS Farm Service Agency Farm Bureau Land Use Committee Monitoring Committee Stream adjacent property owners | Farm Bill Programs Grant?? |
| | <ul style="list-style-type: none"> Increase Farm Bill participation for fencing, wetland construction/protection, and nutrient management plans | <ul style="list-style-type: none"> Identify critical areas for CREP and EQIP sign-up Find funding to cost-share on nutrient management plans to assist with EQIP sign-up Contact appropriate landowners Provide information session about program benefits and assistance Provide stream monitoring to evaluate project goals of selected large scale projects | ESWCD NRCS Farm Service Agency Farm Bureau Land Use Committee Monitoring Committee Producers | Farm Bill Programs Grant?? |
| | <ul style="list-style-type: none"> Develop a balanced growth template model using OWC that utilizes smart growth principles | <ul style="list-style-type: none"> Identify funding for project Identify key stakeholder to develop a comprehensive development plan on a watershed scale for OWC Combine research on pollution related to land use, current trends in development, and infrastructure planning with smart growth principals to develop comprehensive plan for the watershed. Share plan with public and associated officials Discuss its practical use as a tool for updating local plans | Berlin Heights Village Council Berlin Twp Erie County Commissioners Erie Regional Planning OCTP Erie County Engineer DOES ESWCD WRLC Lake Erie Commission Land Use Committee | Local funding Grant |

| Goal | Objective | Action Items | Agency/Groups | Funds |
|--|--|--|--|-------------------------|
| Reduce Sediment and Nutrient Loading in OWC (TMDL requirement) | <ul style="list-style-type: none"> Assess nutrient and bacterial pollution as a result of failing septic systems located in the Berlin Heights area and identify possible solutions for the community | <ul style="list-style-type: none"> Establish funding for completed proposal Follow project design plan as stated in CMAG proposal Provide information at FCT public meetings Assist in stream monitoring efforts and data analysis | ECGHD ESWCD OWC NERR Berlin Heights Village Council Monitoring Committee Source Contaminant Committee | Local Funds Grant(s) |
| | <ul style="list-style-type: none"> Improve awareness of septic system maintenance practices | <ul style="list-style-type: none"> Establish funding for educational events Develop workshop details and materials Advertise workshop Hold Workshop Evaluate success of workshop Utilize materials and portions of workshop to use at other events | ECGHD DOES Source Contaminant Committee | OEEF Grants |

| Goal | Objective | Action Items | Agency/Groups | Funds |
|------|--|--|--|----------|
| | <ul style="list-style-type: none"> Restore bottomland wooded wetlands in OWC Reserve | <ul style="list-style-type: none"> Assess site for restoration Develop work plan and timeline Mobilize timeline Implement project planting Monitor to tree mortality and invasive species Evaluate success of project | OWC NERR FOWC EMP ODNR - DOW Stream Habitat and Restoration Committee | OWC NERR |
| | <ul style="list-style-type: none"> Streambank erosion control where stream has been influenced by human land use changes | <ul style="list-style-type: none"> Identify areas of severe erosion Select several projects to demonstrate different technologies in erosion control Developing funding strategy for projects Contact landowners for assistance with erosion control of streambank Develop work plan, budget, and timeline Mobilize timeline Implement project (outside contracting) Identify demo sites for future tour of BMP successes Evaluate success of each project | OWC NERR ESWCD FPCW FOWC EMP ODNR – DOW Erie County Engineer Eco Associates Inc. Stream Habitat and Restoration Committee Stream adjacent property owners | Grant(s) |
| | <ul style="list-style-type: none"> Enhancement of stream development for possible “Wild School” site to provide students a nearby natural exploration lab | <ul style="list-style-type: none"> Identify areas of poor in-stream habitat due to sediment/nutrient loading (ie. Berlin Heights) Identify possible solution to issue Developing funding strategy for project Contact appropriate landowners for project Develop work plan, budget, and timeline Mobilize timeline Implement project (outside contracting) Evaluate success of project through QHEI and macroinvertebrate sampling Utilize site for future stream education | OWC NERR EMP Berlin Milan Schools ODNR – DOW Berlin Heights Village Council Eco Associates Inc. FOWC FPCW ESWCD Stream Habitat and Restoration Committee Education Committee | Grant(s) |

| | | | | |
|--|---|---|--|---------------------|
| Enhance and protect in-stream and Riparian wildlife habitat in OWC | <ul style="list-style-type: none"> Invasive species control | <ul style="list-style-type: none"> Identify areas of critical importance for invasive species removal Developing funding strategy for projects Contact landowners for project approval Develop work plan, budget, and timeline Educate public on invasive species and project Mobilize timeline Evaluate success with yearly site visits | OWC NERR ODNR Stream Habitat and Restoration Committee | Grant |
| | <ul style="list-style-type: none"> Work with public officials and communities to develop wetland and riparian setback ordinances | <ul style="list-style-type: none"> Organize meetings and data to begin discussion of Setback ordinances Facilitate planning process Identify available education resources to aid in process Establish funding for technical assistance Hold public education meetings about setbacks Create factsheet/brochure about local setback regulations | OWC NERR OCTP ESWCD DOES Erie County Engineer Berlin Heights Village Council Berlin Twp Erie County Commissioners Erie Regional Planning Lake Erie Commission Land Use Committee | Local Funding Grant |
| | <ul style="list-style-type: none"> Educate stream adjacent landowners on importance of riparian buffers | <ul style="list-style-type: none"> Purchase and Distribute "Life at the Waters Edge" to selected landowners Provide workshop to develop BMPs as established in book Set up tours of selected properties to "showcase" BMPs of residents | EMP ESWCD OWC NERR Education Committee | Grant |
| | <ul style="list-style-type: none"> Partner with land conservation interests to promote conservation and farmland preservation within OWC watershed | <ul style="list-style-type: none"> Assistance WRLC in completing goals established in the anchor strategy for OWC through landowner contacts and educational meetings | WRLC OWC NERR EMP Farm Bureau Land Use Committee | WRLC |

| Goal | Objective | Action Items | Agency/Groups | Funds |
|--|---|--|---|------------------------|
| Improve stormwater management strategies and reduce run-off related pollution within the Fire lands area | <ul style="list-style-type: none"> Develop spill emergency plan for OWC | <ul style="list-style-type: none"> Identify key stakeholders for plan development Assess needs and current resources for establishing an emergency spill plan Establish funding for plan development and implementation Facilitate development of plan Identify and coordinate educational needs to develop plan Facilitate public meetings to educate about potential risks and development of plan | OWC NERR EMA ESCWD DOES Erie County Engineer Berlin Heights Village Council Berlin Twp Erie County Commissioners Erie Regional Planning ODOT | Grant |
| | <ul style="list-style-type: none"> Provide education and demonstrations of stormwater BMPs and proper site design for Public officials, developers, engineers, contractors, etc. | <ul style="list-style-type: none"> Identify sites with existing stormwater BMPs, and new project sites to form demonstration tour for public, private, and officials. Work with local agencies, non-profit, and private groups to hold a local BMP field day. | ESWCD DOES ECGHD Erie County Commissioners Erie County Engineer | Grant |
| | <ul style="list-style-type: none"> Provide education on updates to stormwater regulations | <ul style="list-style-type: none"> Assist with education and outreach of newly updated stormwater regulations for the area. | Erie County Commissioners Erie County Engineer ESWCD DOES | Local Funding |
| | <ul style="list-style-type: none"> Enhance efforts for identifying and resolving construction related run-off pollutant loading | <ul style="list-style-type: none"> Coordinate education for public officials and staff about construction pollution and BMPs Facilitate assessment of current construction activity compliance with stormwater regulations | ESWCD DOES ECGHD Erie County Commissioners Erie County Engineer | Local Funding |
| | <ul style="list-style-type: none"> Enhance education efforts on resident connection to run-off related pollutants | <ul style="list-style-type: none"> Identify current guidance and materials on resident pollution Distribute information through public events Hold workshop or create presentation to be used at educational events on reducing run-off pollution for the homeowner | ESWCD DOES ECGHD Erie County Commissioners Erie County Engineer Education Committee | Local Funding Grant |

| Goal | Objective | Action Items | Agency/Groups | Funds |
|--|---|--|--|-----------------------------------|
| Enhance watershed stewardship activities in Firelands area | <ul style="list-style-type: none"> Coordinate outreach and use of existing programs with partnering agencies | <ul style="list-style-type: none"> Aid in community awareness of existing programs Identify appropriate target audiences for existing educational programs Provide train-the-trainer to expand use of educational resources Utilize volunteer educators to fill "gaps" in staffing of educational events | ESWCD OWC NERR EMP DOES BGSU FOWC FPCW Education Committee | OEEF |
| | <ul style="list-style-type: none"> Provide volunteer opportunities such as stream clean-ups | <ul style="list-style-type: none"> Identify areas for potential clean-up events Contact appropriate landowners for permission Develop partnerships and sponsorships for event Identify individual/group to lead the event Contact volunteer base Provide incentive for volunteers Hold at least one clean-up a year Contact appropriate media for event Evaluate and document event success | DOES SRWC ESWCD OWC NERR EMP FOWC FPCW Stream Habitat and Restoration Committee | DOES OEEF |
| | <ul style="list-style-type: none"> Continue to maintain and expand volunteer monitoring group | <ul style="list-style-type: none"> Submit Monitoring plan to OEPA Provide two training sessions for volunteers Assist with EPA level one and two certification of volunteers Identify an individual to coordinate stream monitoring plan Continue to build volunteer base Utilize BGSU students for additional testing Establish additional funding for program Form data collection system Document monitoring efforts on website Provide monitoring results after each yearly cycle. | OWC NERR ESWCD BGSU Sandusky Waste Water Treatment Plant FPCW Monitoring Committee Tribes Team volunteers National Honors Society DOES | Local funding OEEF Grant(s) |
| | <ul style="list-style-type: none"> Develop and implement rain garden, eco-landscaping workshops | <ul style="list-style-type: none"> Establish funding for educational events Develop workshop details and materials Advertise workshop Hold Workshop Evaluate success of workshop Utilize materials and portions of workshop to use at other events | ECGHD HCGHD ESWCD OWC NERR OSU EXT Meadow Environments LLC Local Nurseries Source Contaminant Committee Education Committee DOES | OEEF |
| | <ul style="list-style-type: none"> Provide community outreach through new letters and website | <ul style="list-style-type: none"> Update website monthly Increase website content based on community requests and program development Develop and distribute 4 newsletters a year Find ways to expand content and distribution of newsletter (i.e. funding) | Education Committee FOWC FPCW DOES | OWC NERR FOWC |

| Goal | Objective | Action Items | Agency/Groups | Funds |
|------------------------|--|---|-----------------------|-------------------------|
| Program sustainability | <ul style="list-style-type: none"> Establish permanent funding for coordinator position | <ul style="list-style-type: none"> Identify current funding sources Identify collection method and fiscal administrator for funds | WSC Advisory Board | Local Funds Grant(s) |
| | <ul style="list-style-type: none"> Develop general operating budget for FCT program | <ul style="list-style-type: none"> Develop budget items for ongoing projects Itemize general spending detail Provide future projects of budget needs | WSC Advisory Board | N/A |
| | <ul style="list-style-type: none"> Establish permanent funding for general program operations | <ul style="list-style-type: none"> Identify current funding sources Identify collection method and fiscal administrator for funds | WSC Advisory Board | Local Funds |

Drafted: February 15, 2008

Last Updated: July 9, 2008

Breann Hohman, Watershed Coordinator

Abbreviations

| | |
|----------|---|
| BGSU | Bowling Green State University |
| DOES | Erie County Department of Environmental Services |
| ECGHD | Erie County General Health District |
| EMA | Emergency Management Agency |
| EMP | Erie Metroparks |
| ESWCD | Erie Soil and Water Conservation District |
| FOWC | Friends of Old Woman Creek |
| FPCW | Friends of Pipe Creek Watershed |
| HCGHD | Huron County General Health District |
| NRCS | Natural Resource Conservation Service |
| OCTP | Ohio Coastal Training Program |
| ODOT | Ohio Department of Transportation |
| ODNR DOW | Ohio Department of Natural Resources Division of Wildlife |
| OSU EXT | Ohio State University Extension |
| OWC NERR | Old Woman Creek National Estuarine Research Reserve |
| SRWC | Sandusky River Watershed Coalition |
| WRLC | West Reserve Land Conservancy |
| WSC | Watershed Coordinator |

Appendix D. Volunteer Monitoring Study Plan

Old Woman Creek and Pipe Creek Volunteer Stream Monitoring Study Plan

Firelands Coastal Tributaries Watershed Program

Compiled By: Breann Hohman, Watershed Coordinator

Prepared By:

FCT Monitoring Committee

David Klarer, Ph.D.

Linda Cornell, Ph.D.

Barry Riddle

Charles Herdendorf, Ph.D.

Bob Sennish

Doug Keller

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| Data Management | Page 9 |

Appendices

- Appendix A FCT Tribes Team Stream Monitor Handbook**
- Appendix B Laboratory Operating Standards**
- Appendix C Data Sheets**
- Appendix D Sampling Site Location Maps and Photos**
- Appendix E Sampling Timeline**
- Appendix F Contact List**

Old Woman Creek and Pipe Creek Volunteer Stream Monitoring Study Plan

The purpose of the Tribs Team

The purpose of the “Tribes Team” Volunteer Stream Monitoring Project is to enhance stewardship and ownership of Old Woman Creek and Pipe Creek watersheds by increasing knowledge of local water quality. The objective of this project is to provide credible data to the state and local community for the use of education and eventually problem identification and project evaluation of future management strategies.

Goals

The goals for developing and implementing the volunteer stream monitoring program have been formed into “stages”. The first stage will organize the volunteers, increase public awareness and involvement in watershed stewardship practices, and provide opportunities for additional partnerships with local agencies, civic groups, and schools. The second stage will expand the scope of the monitoring study to reflect community support and information needs as well as begin the credible data certification process through the Ohio Environmental Protection Agency (OEPA). The third and final stage will be completing the requirements for credible data sampling to allow data to be utilized for problem identification and evaluation of watershed stewardship efforts.

Organize and engage volunteers, the program will

- Provide volunteer opportunities for stream monitoring through several public notifications
- Provide initial training for volunteers and inform them of additional training opportunities provided by other agencies
- Aid in data collection, data management and analysis
- Share results with other volunteers, agencies, schools, and local public
- Encourage feedback and evaluation of the Study Plan for future improvement and expansion

Involve agency partnerships

- Increase communication and opportunities for partnerships with federal, state, and local agencies, as well as local volunteer groups
- Increase staff participation and support through implementation and use of data

Collect and manage data

- Identify protocols for volunteer monitoring that will provide valid credible data
- Ensure consistency and accuracy of data collection, analysis, and reporting
- Evaluate and update sampling techniques to reduce sampling error
- Provide continued training for volunteers
- Evaluate and update data management techniques as needed
- Provide useful and concise result summaries of data to enhance the watershed perspective

Data Usage

The initial users of this data will be the local watershed groups, stream monitoring volunteers, and local school districts for educational purposes. The data will form a baseline for developing trend analysis of water quality within the sampled watershed, comparative analysis between reaches within one watershed, and comparative analysis of the two sampled watersheds. Initial sampling will allow for calibration of the volunteers sampling technique. The actual baseline to be created by volunteer monitoring will be developed once data is considered creditable by standards detailed in the QA/QC section. After the initial baseline is created, the Study Plan will be evaluated and updated to begin trend analysis and add additional monitoring parameters.

Test Parameters/Test Protocol

Approved volunteers will perform field tests at each site for the following parameters temperature, pH, dissolved oxygen, and turbidity. Grab samples will also be taken for laboratory testing for the following parameters: conductivity, ammonia, nitrate, and soluble reactive phosphorus. Grab samples are required to be promptly submitted to the appropriate laboratory as directed in the volunteer handbook (Appendix A). Complete test parameter protocol descriptions for both in-field and laboratory settings and water quality sampling data sheets are included in Appendix A, B, and C respectively.

| Parameter | Analysis Tool/Method | Accuracy | Range |
|--------------------------------|----------------------|------------------|---------------------|
| Temperature* | Hach Pocket Pal | ±0.1°C | -15 to 170°C |
| pH* | Hach Pocket Pal | ±0.1pH at 20°C | 0.0 to 14.0 |
| Dissolved Oxygen* | Hach Kit Model OX-2P | 0.2 mg/L | 0.2-4 and 1-20 mg/L |
| Turbidity** | Ohio Sediment Tube© | 90% TSS accuracy | 0-36in |
| Soluble reactive phosphorus*** | | | |
| Nitrates*** | | | |
| Conductivity*** | | | |
| | | | |

*Information obtained from Hach product manual.

**Purchased from Lake County Soil and Water Conservation District.

***See laboratory standard located in Appendix.

Sample Sites

Sampling locations chosen at Old Woman Creek and Pipe Creek were selected to provide representation of the watershed as a whole and provide comparable data sets both among and within each watershed. Factors included in site selection included but were not limited to surrounding land use, drainage area, accessibility, practicability of sampling for specific parameters, and previously recorded water quality data. Land uses of Old Woman Creek are mainly agricultural with one municipality and several wooded areas including corridor sections of the stream. Pipe Creek watershed has a diverse group of land uses, including agriculture, high-density and low-density urban, quarry, and industry. Old Woman Creek may serve as a suitable reference watershed for enhancement efforts in Pipe Creek due to its relatively undeveloped land. See Appendix D photos and location maps for each sample site and sampling area map.

Old Woman Creek

Liles Road Bridge (located near Cable Rd)

- Description
 - This site is located in upper headwater region of the eastern branch. Surrounding land use is agricultural row-crop fields. The site has filter strips with vegetation reaching to the waters edge; however it still experiencing slumping of the side slopes. Field tile outlets are protruding out of bank indicating signs of erosion. One field tile is located within access of bridge.
- Tests
 - Test parameters for this site include all listed chemical analysis, streambank erosion, and turbidity.
- Challenges
 - This site will not be acceptable for year round sampling as well as macroinvertebrate sampling due to periods of dry channel bed.

Tenant Rd Bridge (located near Collins Rd)

- Description
 - This site is located in the headwater region of the western branch. Surrounding land use is low forested floodplain used periodically for cattle grazing. Floodplain is well established. Stream features include well established riffle located on the south side of bridge. (plenty of room to park) This site is also unique in that the bridge culvert has been modified to a modern design.
- Tests
 - Test parameters for this site include all listed chemical analysis as well as turbidity, and macroinvertebrate.
- Challenges
 - In order to sample within the riffle zone of the stream, permission would be needed to gain access on private property.

Hoffman Preserve (located on Huff Rd near Chapin Rd)

- Description
 - This site is located within a preserve owned by Erie Metroparks. The sampling location is located within the forested portion of the preserve with an easy access trail down to the stream and adjacent floodplain. Streambed boasts established riffle and pool sites perfect for macroinvertebrate sampling.
- Tests
 - Test parameters for this site include all listed chemical analysis as well as turbidity, and macroinvertebrate.
- Challenges
 - No apparent challenges. EMP will need notification of sampling practices taking place at site.

Chapin Road (Near Barrows Rd, Bow-N-Barrels)

- Description
 - This site has a bridge access but may also be accessed upstream where stream channel runs near road. The land use at this site is a combination of residential (turf grass) and forested use. Streambed shows signs of heavy siltation making this site unsuitable for macroinvertebrate sampling.
- Tests
 - Test parameters for this site include all listed chemical analysis, streambank erosion, and turbidity.
- Challenges
 - This site may need permission from landowner for access.

Berlin Rd (Near Barrows Rd)

- Description
 - This site is the location of a well established vernal pool adjacent to the stream. Surrounding land use includes railroad tracks and forested floodplain. This site is also located downstream of the joining of the east and west branches of Old Woman Creek. Additional information is recorded at this site through a USGS gauge station.
- Tests
 - Test parameters for this site include all listed chemical analysis as well as turbidity, and macroinvertebrate.
- Challenges
 - This site would make an excellent site for possible easement to sustain future research (stream and vernal pool area). John Battle owns property south of bridge and his mother owns the property to the north of bridge.

Berlin Road (Near Ohio Turnpike)

- Description
 - This site is located adjacent to the old water treatment plant of Berlin Heights. A portion of the stream located upstream of the proposed sample site has been filled with concrete creating a dam on the stream flow. A well established riffle site is

located south approximately 300ft from road access. This site is located downstream of Berlin Heights.

- Tests
 - Test parameters for this site include all listed chemical analysis as well as turbidity, and macroinvertebrate
- Challenges
 - Access to this site is difficult compared to other sites. Permission to access site will also need to be received from property owner, Mark Suhanick.

Bellamy Rd

- Description
 - This site has rocky streambed characteristics. Surrounding land use includes both residential and row-crop agricultural fields. This site is upstream of the Berlin Heights.
- Tests
 - Test parameters for this site include all listed chemical analysis as well as turbidity, and macroinvertebrate.
- Challenges
 - Site access will need permission from landowner.

Additional Sites Possible

- Western portion of Berlin Road (Check for access point). There will be a new cattle operation opening on that reach.
- Ron Nemire's property (located within Berlin Heights) downstream of Pegasus Equestrian Farm.

Pipe Creek

Strecker Road

- Description
 - This site is upstream of one of the Parkertown Quarry dewatering pump outlets (the other is on Mills Creek). The streambed is expected to be embedded with silt deposits. Surrounding land use includes row-crop agriculture and one residence upstream of sampling site. Grass buffers are located on stream bank downstream of sampling site. Narrow wooded buffer is located on one side of bank upstream of sampling site.
- Tests
 - Test parameters for this site include all listed chemical analysis, stream bank erosion, QHEI, and turbidity.
- Challenges
 - Landowner permission for stream access.

Harris Road

- Description
 - This site is located near the Ohio Turnpike. Stream substrate consists of gravel and rock. The site is a narrow ditch immediately covered by narrow dense wood plot on one side. Surrounding land use includes row-crop agriculture and residential. Residential land adjacent to stream has left no buffer.
- Tests
 - Test parameters for this site include all listed chemical analysis, stream bank erosion, QHEI, and turbidity.
- Challenges
 - Landowner permission for stream access.

Patten Tract Road

- Description
 - The stream bed at this site consists of some sand and gravel and high amounts of sediment deposits. Surrounding land use includes residential and row-crop agriculture. There is a narrow wooded buffer on the stream upstream of the sampling site. Sediment deposits have created a sandbar in the center of the stream channel below the road bridge diverting the stream into two channels and reconnecting several linear feet downstream. The site is heavily covered with in-stream vegetation including grass, sedge, and willow species.
- Tests
 - Test parameters for this site include all listed chemical analysis and turbidity.
- Challenges
 - Landowner permission for stream access.

Bogart Road

- Description
 - This site consists of a rocky substrate with riffle site located upstream of road bridge. Surrounding land use consist of both residential and row-crop agriculture. Wooded corridor is located upstream of sampling site and grass/shrub buffer located downstream of sampling site. This site has heavy in-stream vegetative cover.
- Tests
 - Test parameters for this site include all listed chemical analysis as well as turbidity, QHEI, and macroinvertebrate.
- Challenges
 - Site access will need permission from landowner.

Campbell Street

- Description
 - This site consists of a narrow wooded corridor buffering the stream. Surrounding land use consists of wooded area and row-crop agriculture upstream of the site and commercial and residential development both at the site and downstream of the site.
- Tests
 - Test parameters for this site include all listed chemical analysis and turbidity.
- Challenges
 - Landowner permission for stream access.

Columbus Ave.

- Description
 - This site consists of rocky substrate and riffle site located downstream of the road bridge. Surrounding land use consists of urban development. Stream corridor is narrow; vegetation is mainly scrub shrub and small trees. Some emergent vegetation is located within the streamway.
- Tests
 - Test parameters for this site include all listed chemical analysis as well as turbidity, and macroinvertebrate.
- Challenges
 - Site access will need permission from landowner.

Perkins Ave.

- Description
 - The depths at this site vary reaching depths of about 4-5ft in some areas. Stream bed is limestone bedrock with some sediment deposition. Narrow buffer of mature trees and shrubs buffer the stream. Upstream of sampling site consist of narrow mature tree buffer, rock fill, bare banks and retaining wall. This site experiences back water effects from Lake Erie reducing the amount of erosion despite lack of vegetation on some banks.
- Tests
 - Test parameters for this site include all listed chemical analysis and turbidity.
- Challenges
 - Site access will need permission from landowner.

Timeline

Chemical sampling will occur once a month within the 3rd week except for November which will occur during the 2nd week. For safety reasons of our volunteers each sampling year will range from March thru November. This program will start in October of 2007 implementing chemical monitoring only as a pilot to evaluate sampling timeline practicability and sampling protocol. In the spring of 2008 additional training will be provided to volunteers allowing the expansion of the monitoring program to include physical and biological sampling methods. See Appendix E for complete sampling timeline.

Creditable Data

Manufactures recommendations and instructions will be followed for all purchased field equipment. Pocket Pal meters will be calibrated by program supervisors according to manufacture's instructions before each sampling use. The pH Pocket Pal meter will be calibrated using buffer solutions of pH 7.0 and pH 10.0. To ensure quality assurance and control of the data collected each month of sampling two samplings location will be randomly selected in each watershed for a replicate field and laboratory samples. Ohio Sediment Tube© readings will be taken twice at each location. Reading will be taken facing way from the sun. If first two samples do not agree within an accepted margin, a third sample will need to be taken. Final reading will be recorded as an average of the two similar readings. If the Secchi symbol is visible when the tube is full, the measurement recorded shall be "36in+".

All grab sample bottles and DO equipment will be cleaned in the lab prior to field sampling. All reagents will be used or disposed of prior to expiration date.

To ensure that the data collected through volunteers is consistent and accurate; volunteers will have both training and testing administered through the program. Initial training will be provided by supervisors of the program as well as random testing over the course of the sampling year. Training will be provided by the program in the spring and fall of each sampling year. Volunteers will also be notified of additional training provided by other agencies. Volunteers will be require to complete two training sessions within the first year of sampling and one follow-up session each additional year of participation.

To evaluate techniques utilized in this study plan volunteers will be encouraged to provide feedback of challenges and suggestions for improving the plan. At the end of each year all comments and suggestions provided by the volunteers will be combined to update the study plan accordingly by a committee comprised of supervisors, interested volunteers, and the members of the FCT Monitoring Committee (See Appendix E for complete contact list).

Data Management

All data collected will be submitted to the identified supervisor for that watershed. The data will be electronically stored and analyzed by the supervisor at the end of each sampling year. It is the responsibility to recognize outliers in the data collected which may indicate sampling error and investigate the accuracy and consistency of the volunteer. At the end of each year (after November's sampling event) the supervisor(s), Monitoring Committee, and interested volunteers will analyze the data and develop a summary report of the results to be distributed to volunteers and made available to the public in February of the following year.

Appendix A

FCT Tribs Team Stream Monitor Handbook

Basic Concepts

Watersheds

A watershed is the area of land from which runoff (from rain, snow, and springs) drains to a stream, river, lake, or other body of water (Fig. 2.1). Its boundaries can be identified by locating the highest points of lands around the waterbody. Streams and rivers function as the "arteries" of the watershed. They drain water from the land as they flow from higher to lower elevations.

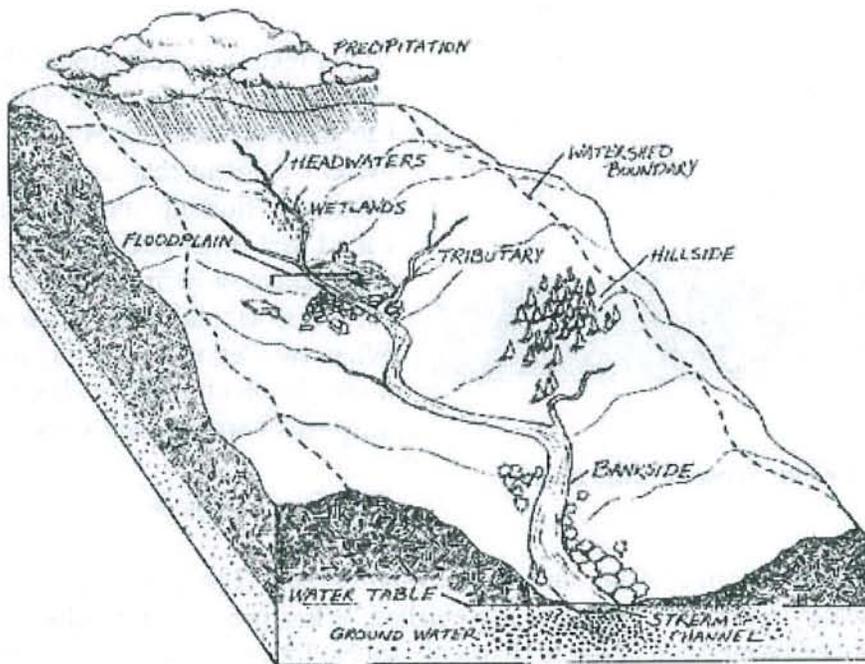


Figure 2.1

Cross section of a watershed

Volunteers should get to know the watersheds of their study streams.

A watershed can be as small or as large as you care to define it. This is because several watersheds of small streams usually exist within the watershed of a larger river. The watershed of the Mississippi River, for example, is about 1.2 million square miles and contains thousands of smaller watersheds, each defined by a tributary stream that eventually drains into a larger river like the Ohio River or Missouri River and to the Mississippi itself.

The River System

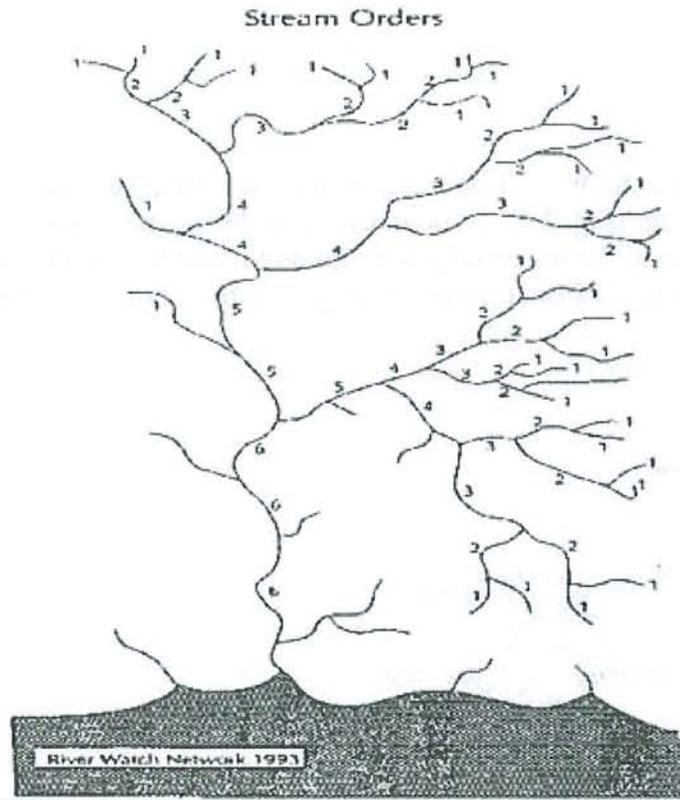


Figure 2.2

A representation of a river network with stream order marked

The water cycle is the movement of water through the environment (Fig. 2.3). It is through this movement that water in the river system is replenished. When precipitation falls to earth in a natural (undeveloped) watershed in the midAtlantic states, for example, about 40 percent will be returned to the atmosphere by evaporation or transpiration (loss of water vapor by plants). About 50 percent will percolate stream channel, the ground water is discharged into the stream as a spring. The combination of ground water discharges to a stream is defined as its baseflow. At times when there is no surface runoff, the entire flow of a stream might actually be baseflow from ground water (Fig. 2.5).

As streams flow downhill and meet other streams in the watershed, a branching network is formed (Fig. 2.2). When observed from the air this network resembles a tree. The trunk of the tree is represented by the largest river that flows into the ocean or large lake. The "tipmost" branches are the headwater streams. This network of flowing water from the headwater streams to the mouth of the largest river is called the river system.

Water resource professionals have developed a simple method of categorizing the streams in the river system. Streams that have no tributaries flowing into them are called first-order streams. Streams that receive only first-order streams are called second-order streams. When two second-order streams meet, the combined flow becomes a third-order stream, and so on.

The Water Cycle

Some streams, on the other hand, constantly lose water to the ground water. This occurs when the water table is below the bottom of the stream channel. Stream water percolates down through the soil until it reaches the zone of saturation. Other streams alternate between losing and gaining water as the water table moves up and down according to the seasonal conditions or pumpage by area wells.

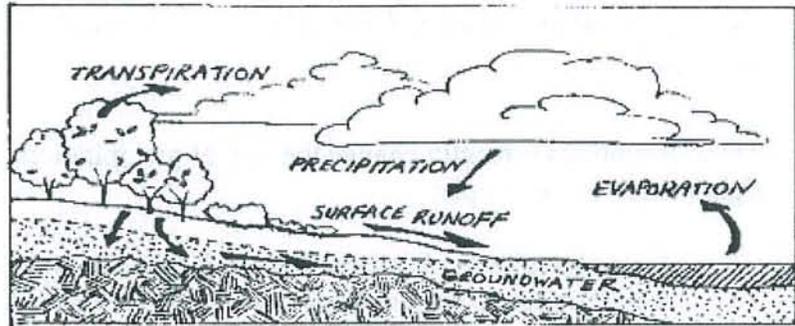


Figure 2.3

The water cycle

Water moving through the water cycle replenishes streams in the watershed.

The interactions between the watershed, soils, and water cycle define the natural water flow (hydrology) of any particular stream. Most significant is the fact that developed land is more impervious than natural land. Instead of percolating into the ground, rain hits the hard surfaces of buildings, pavement, and compacted ground and runs off into a storm drain or other artificial structure designed to move water quickly away from developed areas and into a natural watercourse.

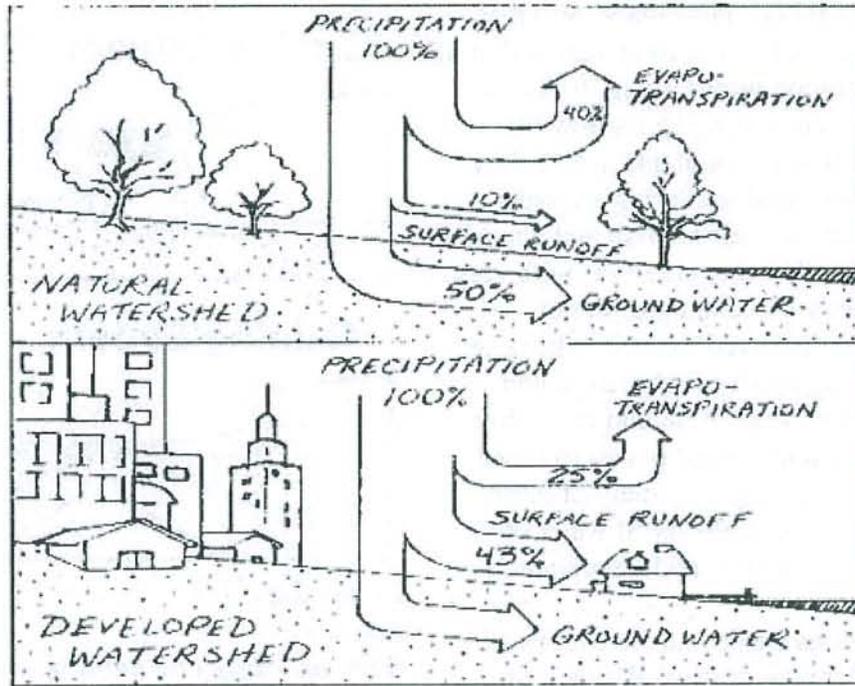


Figure 2.4

The fate of precipitation in undeveloped vs. developed watersheds

Surface runoff increases and ground water recharge decreases as watersheds become developed.

These conditions typically change the fate of precipitation in the water cycle (See Fig. 2.4, right panel). For example:

- Less precipitation is evaporated back to the atmosphere. (Water is transported rapidly away via storm drains and is not allowed to stand in pools.)
- Less precipitation is transpired back to the atmosphere from plants. (Natural vegetation is replaced by buildings, pavement, etc.)
- Less precipitation percolates through the soil to become ground water. (This can result in a lower water table and can affect baseflow.)
- More surface runoff is generated and transported to streams. (Streamflow becomes more intense during and immediately after storms.)

Chapter 3, Watershed Survey Methods, is designed to help volunteers learn about their watershed. Using the watershed survey approach, they will become familiar with their watershed's boundaries, its hydrologic features, and the human uses of land and water that might be affecting the quality of the streams within it.

The Living Stream Environment

A healthy stream is a busy place. Wildlife and birds find shelter and food near and in its waters. Vegetation grows along its banks, shading the stream, slowing its flow in rainstorms, filtering pollutants before they enter the stream, and sheltering animals. Within the stream itself are fish and a myriad of insects and other tiny creatures with very particular needs. For example, stream dwellers need dissolved oxygen to breathe; rocks, overhanging tree limbs, logs, and roots for shelter; vegetation and other tiny animals to eat; and special places to breed and hatch their young. For many of these activities, they might also need water of specific velocity, depth, and temperature.

Human activities shape and alter many of these stream characteristics. We dam up, straighten, divert, dredge, dewater, and discharge to streams. We build roads, parking lots, homes, offices, golf courses, and factories in the watershed. We farm,

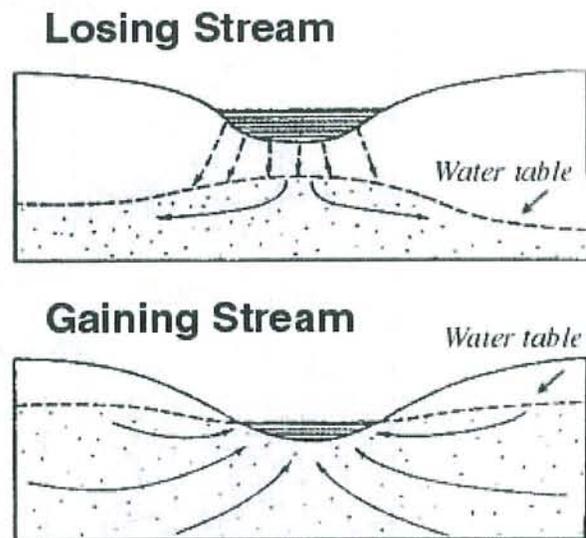


Figure 2.5

Streams losing and gaining water

The position of the water table sometimes plays a role in determining the amount of streamflow.

mine, cut down trees, and graze our livestock in and along stream edges. We also swim, fish, and canoe in the streams themselves.

These activities can dramatically affect the many components of the living stream environment (Fig. 2.6). These components include:

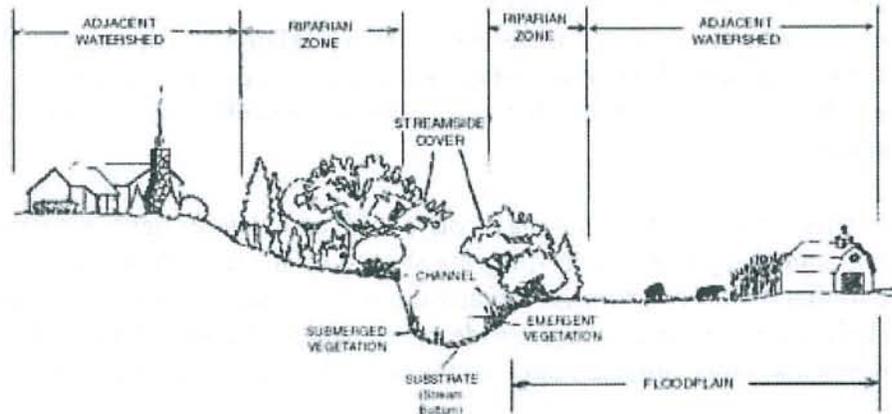


Figure 2.6

Components of the stream system

Volunteers should be aware that the surrounding land affects stream habitat.

1. The *adjacent watershed* includes the higher ground that captures runoff and drains to the stream. For purposes of this manual, the adjacent watershed is defined as land extending from the riparian zone to 1/4 mile from the stream.
2. The *floodplain* is the low area of land that surrounds a stream and holds the overflow of water during a flood.
3. The *riparian zone* is the area of natural vegetation extending outward from the edge of the stream bank. The riparian zone is a buffer to pollutants entering a stream from runoff, controls erosion, and provides stream habitat and nutrient input into the stream. A healthy stream system generally has a healthy riparian zone. Reductions and impairment of riparian zones occur when roads, parking lots, fields, lawns, and other artificially cultivated areas, bare soil, rocks, or buildings are near the stream bank.
4. The *stream bank* includes both an upper bank and a lower bank. The lower bank normally begins at the normal water line and runs to the bottom of the stream. The upper bank extends from the break in the normal slope of the surrounding land to the normal high water line.
5. The *streamside cover* includes any overhanging vegetation that offers protection and shading for the stream and its aquatic inhabitants.
6. *Stream vegetation* includes emergent, submergent, and floating plants. Emergent plants include plants with true stems, roots, and leaves with most of their vegetative parts above the water. Submergent plants also include some of the same types of plants, but they are completely immersed in water. Floating plants (e.g., duckweed, algae mats) are detached from any substrate and are therefore drifting in the water.

7. The *channel* of the streambed is the zone of the stream cross section that is usually submerged and totally aquatic.
8. *Pools* are distinct habitats within the stream where the velocity of the water is reduced and the depth of the water is greater than that of most other stream areas. A pool usually has soft bottom sediments.
9. *Riffles* are shallow, turbulent, but swiftly flowing stretches of water that flow over partially or totally submerged rocks.
10. *Runs* or *glides* are sections of the stream with a relatively low velocity that flow gently and smoothly with little or no turbulence at the surface of the water.
11. The *substrate* is the material that makes up the streambed, such as clay, cobbles, or boulders.

Whether streams are active, fast moving, shady, cold, and clear or deep, slowmoving, muddy, and warm--or something in between--they are shaped by the land they flow through and by what we do to that land. For example, vegetation in the stream's riparian zone protects and serves as a buffer for the stream's streamside cover, which in turn shades and enriches (by dropping leaves and other organic material) the water in the stream channel.

Furthermore, the riparian zone helps maintain the stability of the stream bank by binding soils through root systems and helps control erosion and prevent excessive siltation of the stream's substrate. If human activities begin to degrade the stream's riparian zone, each of these stream components--and the aquatic insects, fish, and plants that inhabit them--also begins to degrade. Chapter 4 includes methods that volunteers can use to assess the stream's living environment--specifically, the insects that live in the stream and the physical components of the stream (the habitats) that support them.

Water Quality

The water in a stream is always moving and mixing, both from top to bottom and from one side of the stream to the other. Pollutants that enter the stream travel some distance before they are thoroughly mixed throughout the flow. For example, water upstream of a pipe discharging wastewater might be clean. At the discharge site and immediately downstream, the water might be extremely degraded. Further downstream, in the recovery zone, overall quality might improve as pollutants are diluted with more water. Far downstream the stream as a whole might be relatively clean again. Unfortunately, most streams with one source of pollution often are affected by many others as well.

Pollution is broadly divided into two classes according to its source. Point source pollution comes from a clearly identifiable point such as a pipe which discharges directly into a waterbody. Examples of point sources include factories, wastewater treatment plants, and illegal straight pipes from homes and boats.

Nonpoint source pollution comes from surface water runoff. It originates from a broad area and thus can be difficult to identify. Examples of nonpoint sources include agricultural runoff, mine drainage, construction site runoff, and runoff from city streets and parking lots.

Nationally, the pollutants most often found in the stream environment are not toxic substances like lead, mercury, or oil and grease. More impacts are caused by sediments and silt from eroded land and nutrients such as the nitrogen and phosphorus found in fertilizers, detergents, and sewage treatment plant discharges. Other leading pollutants include pathogens such as bacteria, pesticides, and organic enrichment that leads to low levels of dissolved oxygen. Common sources of pollution to streams include:

- *Agricultural activities* such as crop production, cattle grazing, and maintaining livestock in holding areas or feedlots. These contribute pollutants such as sediments, nutrients, pesticides, herbicides, pathogens, and organic enrichment.
- *Municipal dischargers* such as sewage treatment plants which contribute nutrients, pathogens, organic enrichment, and toxicants.
- *Urban runoff* from city streets, parking lots, sidewalks, storm sewers, lawns, golf courses, and building sites. Common pollutants include sediments, nutrients, oxygendemanding substances, road salts, heavy metals, petroleum products, and pathogens.

Other commonly reported sources of pollutants are mining, industrial dischargers (factories), forestry activities, and modifications to stream habitat and hydrology.

Temperature

Why is temperature important?

The rates of biological and chemical processes depend on temperature. Aquatic organisms from microbes to fish are dependent on certain temperature ranges for their optimal health. Optimal temperatures for fish depend on the species: some survive best in colder water, whereas others prefer warmer water. Benthic macroinvertebrates are also sensitive to temperature and will move in the stream to find their optimal temperature. If temperatures are outside this optimal range for a prolonged period of time, organisms are stressed and can die. Temperature is measured in de-grees Fahrenheit (F) or degrees Celsius (C).

For fish, there are two kinds of limiting temperatures the maximum temperature for short exposures and a weekly average temperature that varies according to the time of year and the life cycle stage of the fish species. Reproductive stages (spawning and embryo development) are the most

sensitive stages. Table 5.5 provides temperature criteria for some species.

| Species | Max. weekly average temp. for growth (juveniles) | Max. temp. for survival of short exposure (juveniles) | Max. weekly average temp. for spawning ^a | Max. temp. for embryo spawning ^b | Table 5.5 |
|----------|--|---|---|---|---|
| | | | | | Maximum average temperatures for growth and short- |
| Bluegill | 32 °C (90) | 35 °C (95) | 25 °C (77) | 34 °C (93) | |

Temperature affects the oxygen content of the water (oxygen levels become lower as temperature increases); the rate of photosynthesis by aquatic plants; the metabolic rates of aquatic organisms; and the sensitivity of organisms to toxic wastes, parasites, and diseases.

Causes of temperature change include

weather, removal of shading streambank vegetation, impoundments (a body of water confined by a barrier, such as a dam), dis-charge of cooling water, urban storm water, and groundwater inflows to the stream.

| | °F) | °F) | °F) | °F) | term maximum temperatures for selected fish (°C and ° F) |
|---|---------------|---------------|---------------|---------------|---|
| Brook trout | 19 °C (66 °F) | 24 °C (75 °F) | 9 °C (48 °F) | 13 °C (55 °F) | |
| Common carp | --- | --- | 21 °C (70 °F) | 33 °C (91 °F) | |
| Channel catfish | 32 °C (90 °F) | 35 °C (95 °F) | 27 °C (81 °F) | 29 °C (84 °F) | |
| Largemouth bass | 32 °C (90 °F) | 34 °C (93 °F) | 21 °C (70 °F) | 27 °C (81 °F) | |
| Rainbow trout | 19 °C (66 °F) | 24 °C (75 °F) | 9 °C (48 °F) | 13 °C (55 °F) | |
| Smallmouth bass | 29 °C (84 °F) | --- | 17 °C (63 °F) | 23 °C (73 °F) | |
| a - Optimum or mean of the range of spawning temperatures reported for the species b - Upper temperature for successful incubation and hatching reported for the species c - Upper temperature for spawning | | | | | |
| <i>(Brungs and Jones 1977)</i> | | | | | |

Sampling and Equipment Considerations

Temperature in a stream will vary with width and depth. It can be significantly different in the shaded portion of the water on a sunny day. In a small stream, the temperature will be relatively constant as long as the stream is uniformly in sun or shade. In a large stream, temperature can vary considerably with width and depth regardless of shade. If it is safe to do so, temperature measurements should be collected at varying depths and across the surface of the stream to obtain vertical and horizontal temperature profiles. This can be done at each site at least once to determine the necessity of collecting a profile during each sampling visit. Temperature should be measured at the same place every time.

Temperature is measured in the stream with a thermometer or a meter. Alcohol-filled thermometers are preferred over mercury-filled because they are less hazardous if broken. Armored thermometers for field use can withstand more abuse than unprotected glass thermometers and are worth the additional expense. Meters for other tests, such as pH (acidity) or dissolved oxygen, also measure temperature and can be used instead of a thermometer.

How to sample

The procedures for measuring temperature consist of the following tasks.

TASK 1 Prepare before leaving for the sampling site

Refer to Section 2.3 - Safety Considerations for details on confirming sampling date and time, safety considerations, checking supplies, and checking weather and directions. In addition to the standard sampling equipment and apparel, when measuring temperature you will need:

- A thermometer or meter
- A data sheet for temperature to record results

Be sure to let someone know where you are going and when you expect to return

TASK 2 Measure the temperature

In general, sample away from the streambank in the main current. The outside curve of the stream is often a good place to sample since the main current tends to hug this bank. In shallow stretches, wade into the center current carefully to measure temperature. If wading is not possible, tape your thermometer to an extension pole or use a boat. Reach out from the shore or boat as far as safely possible. If you use an extension pole, read the temperature quickly before it changes to the air temperature.

If you are doing a horizontal or vertical temperature profile, make sure you can safely reach all the points where a measurement is required before trying.

Measure temperature as follows:

1. Place the thermometer or meter probe in the water as least 4 inches below the surface or halfway to the bottom if in a shallow stream.
2. If using a thermometer, allow enough time for it to reach a stable temperature (at least 1 minute). If using a meter, allow the temperature reading to stabilize at a constant temperature reading.
3. If possible, try to read the temperature with the thermometer bulb beneath the water surface. If it is not possible, quickly remove the thermometer and read the temperature.
4. Record the temperature on the field data sheet.

References

Brungs, W.S. and B.R. Jones. 1977. *Temperature Criteria for Freshwater Fish: Protocols and Procedures*. EPA-600/3-77-061. Environ. Research Lab, Ecological Resources Service, U.S. Environmental Protection Agency, Office of Research and Development, Duluth, MN.

pH

What Is pH and why is it important?

pH is a term used to indicate the alkalinity or acidity of a substance as ranked on a scale from 1.0 to 14.0. Acidity increases as the pH gets lower. Fig. 5.9 present the pH of some common liquids.

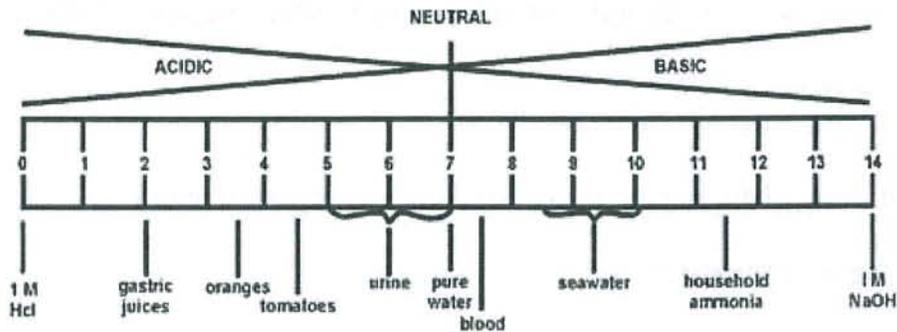


Figure 5.9

pH of selected liquids

pH affects many chemical and biological processes in the water. For example, different organisms flourish within different ranges of pH. The largest variety of aquatic animals prefer a range of 6.5-8.0. pH outside this range reduces the diversity in the stream because it stresses the physiological systems of most organisms and can reduce reproduction. Low pH can also allow toxic elements and compounds to become mobile and "available" for uptake by aquatic plants and animals. This can produce conditions that are toxic to aquatic life, particularly to sensitive species like rainbow trout. Changes in acidity can be caused by atmospheric deposition (acid rain), surrounding rock, and certain wastewater discharges.

The pH scale measures the logarithmic concentration of hydrogen (H^+) and hydroxide (OH^-) ions, which make up water ($H^+ + OH^- = H_2O$). When both types of ions are in equal concentration, the pH is 7.0 or neutral. Below 7.0, the water is acidic (there are more hydrogen ions than hydroxide ions). When the pH is above 7.0, the water is alkaline, or basic (there are more hydroxide ions than hydrogen ions). Since the scale is logarithmic, a drop in the pH by 1.0 unit is equivalent to a 10-fold increase in acidity. So, a water sample with a pH of 5.0 is 10 times as acidic as one with a pH of 6.0, and pH 4.0 is 100 times as acidic as pH 6.0.

pH "Pocket Pals"

pH "pocket pals" are electronic hand-held "pens" that are dipped in the water and provide a digital readout of the pH. They can be calibrated to one pH buffer (lab meters, on the other

hand, can be calibrated to two or more buffer solutions and thus are more accurate over a wide range of pH measurements).

How to collect and analyze samples

The field procedures for collecting and analyzing samples for pH consist of the following tasks.

TASK 1 Prepare before leaving for the sampling site

Refer to Section 2.3 - Safety Considerations for details on confirming sampling date and time, picking up and checking supplies, and checking weather and directions. In addition to the standard sampling equipment and apparel, when sampling for pH, include the following equipment:

- pH "pocket pal"
- Data sheet for pH to record results

Before you leave for the sampling site, be sure to calibrate the pH meter or "pocket pal." The pH meter and "pocket pal" should be calibrated prior to sample analysis and after every 25 samples according to the instructions that come with them.

If you are using a "pocket pal," use the buffer recommended by the manufacturer. Following are notes regarding buffers.

- The buffer solutions should be at room temperature when you calibrate the meter.
- Do not use a buffer after its expiration date.
- Always cap the buffers during storage to prevent contamination.
- Because buffer pH values change with temperature, the meter must have a built-in temperature sensor that automatically standardizes the pH when the meter is calibrated.
- Do not reuse buffer solutions!

TASK 2 Measure pH

The procedure for measuring pH is the same whether it is conducted in the field or lab.

1. If you are using a "pocket pal" or color comparator, follow the manufacturer's instructions.

References

APHA. 1992. *Standard methods for the examination of water and wastewater*. 18th ed. American Public Health Association, Washington, DC. River Watch Network. 1992. Total alkalinity and pH field and laboratory procedures (based on University of Massachusetts Acid Rain Monitoring Project). July 1.

Turbidity

What is turbidity and why is it important?

Turbidity is a measure of water clarity how much the material suspended in water decreases the passage of light through the water. Suspended materials include soil particles (clay, silt, and sand), algae, plankton, microbes, and other substances. These materials are typically in the size range of 0.004 mm (clay) to 1.0 mm (sand). Turbidity can affect the color of the water.

Higher turbidity increases water temperatures because suspended particles absorb more heat. This, in turn, reduces the concentration of dissolved oxygen (DO) because warm water holds less DO than cold. Higher turbidity also reduces the amount of light penetrating the water, which reduces photosynthesis and the production of DO. Suspended materials can clog fish gills, reducing resistance to disease in fish, lowering growth rates, and affecting egg and larval development. As the particles settle, they can blanket the stream bottom, especially in slower waters, and smother fish eggs and benthic macroinvertebrates. Sources of turbidity include:

- Soil erosion
- Waste discharge
- Urban runoff
- Eroding stream banks
- Large numbers of bottom feeders (such as carp), which stir up bottom sediments
- Excessive algal growth.

Sampling and equipment considerations

Turbidity can be useful as an indicator of the effects of runoff from construction, agricultural practices, logging activity, discharges, and other sources. Turbidity often increases sharply during a rainfall, especially in developed watersheds, which typically have relatively high proportions of impervious surfaces. The flow of stormwater runoff from impervious surfaces rapidly increases stream velocity, which increases the erosion rates of streambanks and channels. Turbidity can also rise sharply during dry weather if earth-disturbing activities are occurring in or near a stream without erosion control practices in place.

Regular monitoring of turbidity can help detect trends that might indicate increasing erosion in developing watersheds. However, turbidity is closely related to stream flow and velocity and should be correlated with these factors. Comparisons of the change in turbidity over time, therefore, should be made at the same point at the same flow.

Turbidity is not a measurement of the amount of suspended solids present or the rate of sedimentation of a stream since it measures only the amount of light that is scattered by suspended particles. Measurement of total solids is a more direct measure of the amount of material suspended and dissolved in water (see [section 5.9 - Conductivity](#)).

Turbidity is generally measured by using a turbidity meter. Volunteer programs may also take samples to a lab for analysis.

Another approach is to measure transparency (an integrated measure of light scattering and absorption) instead of turbidity. Water clarity/transparency can be measured using a Secchi disk or transparency tube. The Secchi disk can only be used in deep, slow moving rivers; the transparency tube, a comparatively new development, is gaining acceptance in programs around the country but is not yet in wide use (see using [Transparency Tube](#)).

A turbidity meter consists of a light source that illuminates a water sample and a photoelectric cell that measures the intensity of light scattered at a 90 angle by the particles in the sample. It measures turbidity in nephelometric turbidity units or NTUs. Meters can measure turbidity over a wide range from 0 to 1000 NTUs. A clear mountain stream might have a turbidity of around 1 NTU, whereas a large river like the Mississippi might have a dry-weather turbidity of around 10 NTUs. These values can jump into hundreds of NTU during runoff events. Therefore, the turbidity meter to be used should be reliable over the range in which you will be working. Meters of this quality cost about \$800. Many meters in this price range are designed for field or lab use.

Although turbidity meters can be used in the field, volunteers might want to collect samples and take them to a central point for turbidity measurements. This is because of the expense of the meter (most programs can afford only one and would have to pass it along from site to site, complicating logistics and increasing the risk of damage to the meter) and because the meter includes glass cells that must remain optically clear and free of scratches.

Volunteers can also take turbidity samples to a lab for meter analysis at a reasonable cost.

How to sample

The procedures for collecting samples and analyzing turbidity consist of the following tasks:

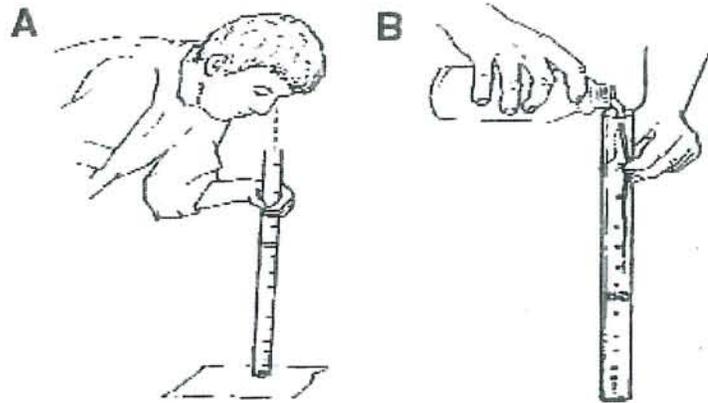


Figure 5.11

Using a transparency tube

(A) Prepare the transparency tube to take a reading. Place the tube on a white surface and look vertically down the tube to see the wave pattern at the bottom.

(B) Slowly pour water sample into the tube stopping intermittently to see if the wave pattern has disappeared.

Fieldsheet for The Ohio Sediment Stick

Developed with a citizen's action mini-grant from
Ohio DNR Division of Soil & Water Conservation

Caution! Your safety is important to us! Please take all necessary precautions whenever you use the Ohio Sediment Stick. Always take the water sample from a safe location. If you cannot wade a stream or river because of high flow conditions, or for any other reason, consider using a bucket that you lower from a bridge or other safe overhang into the stream or river to obtain a water sample to pour into the Sediment Stick. (See "Taking a Sample" below).

Purpose To estimate amount of soil sediment impacting a stream by estimating the turbidity of stream water.

Equipment Needed Sediment stick; tape to measure tenths of a foot; float; time keeping device; calculator.

Taking a Sample Either walk up stream to a point of regular flow or position the sample collecting person along the streambank. Hold the stick halfway between the surface and bottom. When the tube is oriented with it's open end upstream, it will fill with water. If high flow conditions exist, consider using a bucket that you lower from a bridge or safe overhang to collect a sample that can be poured into the Sediment Stick. Continue to keep sample in bucket stirred.

Reading the Stick Holding the stick in your shadow and perpendicular to the ground, pour out water until you can just see the 0.4 inch black dot target on the tube bottom. Rock the tube as needed to keep material suspended. Read the height of the water column from the markings on the stick to the nearest 1/4" (inch). Disregard the color of the water (it may be greenish or brownish); it is the suspended soil material that will affect your view of the target. Repeat this procedure once more. Use the averaged height to estimate total suspended solids (TSS).

Estimating Turbidity Water turbidity refers to the material suspended in the water that refracts light. Ohio EPA uses total suspended solids (TSS) to assess turbidity. You can convert Ohio Sediment Stick readings to TSS by using the conversion table on the back of this field sheet. Use the TSS estimate to calculate sediment load in pounds per day using four steps, also on the back.

Ohio EPA research indicates that Ohio Sediment Stick readings predict a laboratory analysis of TSS at 90%. This is not perfect, but accurate enough to estimate changing sedimentation rates in streams that may be attributed to problems in the upper watershed. Repeated monitoring with the stick establishes how sedimentation rates in your stream are changing due to problems in the upper watershed.

Water Rating You can estimate water quality quickly by using the Stick readings. The conversion table on the back of this field sheet is followed by the water quality scale based on analysis of unimpacted stream data for the state of Ohio.

Lake Soil & Water Conservation District
125 East Erie Street, Painesville Ohio 44077
phone: (440) 350-2730 fax: (440) 350-2601

Disclaimer: The author, publisher, Lake SWCD, and the ODNR are not engaged in rendering specific advice on water quality by this Fieldsheet. The purpose of this Fieldsheet is to provide accurate and authoritative information of a general character only. For advice and assistance on testing the water quality of any streams and rivers at a given time for a specific purpose, the services of a professional should be obtained.

Sources Ken Moore, Elyria Water Works, Lorain, Ohio, unpublished, 1996
Robert Carlson, Ph.D., Kent State University, unpublished, 1996
Paul Anderson & Robert Davic, Ph.D, Ohio EPA Division of Surface Water,
Twinsburg Field Office, 2001, in preparation
Paula Brown, Ohio EPA Modeling Section, Columbus Office, 1998

Estimating Total Suspended Solids: TSS

Use this table to convert Stick readings to an estimate of the weight of solids suspended in the water column. Table is based on research by Anderson and Davic, 2001, in preparation.

| I. Total Suspended Solids: TSS (Turbidity) _____ mg/l | Stick(in) | TSS(mg/l) | Stick(in) | TSS(mg/l) | Stick(in) | TSS(mg/l) |
|---|-----------|-----------|-----------|-----------|-----------|-----------|
| | 0.5 | 1751.2 | 10.0 | 33.7 | 24.0 | 10.6 |
| | 1.0 | 701.9 | 11.0 | 29.7 | 25.0 | 10.1 |
| | 1.5 | 411.2 | 12.0 | 26.5 | 26.0 | 9.6 |
| | 2.0 | 281.4 | 13.0 | 23.8 | 27.0 | 9.1 |
| | 2.5 | 209.6 | 14.0 | 21.6 | 28.0 | 8.7 |
| | 3.0 | 164.8 | 15.0 | 19.7 | 29.0 | 8.3 |
| | 3.5 | 134.5 | 16.0 | 18.1 | 30.0 | 7.9 |
| | 4.0 | 112.8 | 17.0 | 16.7 | 31.0 | 7.6 |
| | 4.5 | 96.6 | 18.0 | 15.5 | 32.0 | 7.3 |
| | 5.0 | 84.0 | 19.0 | 14.4 | 33.0 | 7.0 |
| | 6.0 | 66.1 | 20.0 | 13.5 | 34.0 | 6.7 |
| | 7.0 | 53.9 | 21.0 | 12.7 | 35.0 | 6.5 |
| | 8.0 | 45.2 | 22.0 | 11.9 | ≥ 36.0 = | < 5.0 |
| | 9.0 | 38.7 | 23.0 | 11.2 | | |

| | |
|-------------------------|---|
| II. Water Quality | This scale is based on Ohio statewide reference site data published by Brown, 1988. |
| _____ Excellent | TSS < 10mg/l = excellent water quality |
| _____ Normal | TSS 10-28mg/l = normal water quality |
| _____ Impaired | TSS 29-133mg/l = impaired stream |
| _____ Severely Impaired | TSS > 133mg/l = severely impacted stream |

Estimating Stream Flow: Q

Step 1: Estimate stream flow velocity in feet per second (f/s).

Measure a length of 10 feet in a straight section of stream channel. Record the time it takes a float to move that 10 feet in the area of deepest flow. To get a reliable estimate, make three readings and take the average.

| | |
|------------------|--|
| III. Stream Flow | Reading 1: 10ft ÷ _____ seconds = _____ f/s |
| | Reading 2: 10ft ÷ _____ seconds = _____ f/s |
| Flow Velocity: | Reading 3: 10ft ÷ _____ seconds = _____ f/s |
| _____ f/s | Total = _____ f/s ÷ 3 = _____ average f/s velocity |

Rate of Flow:

Step 2: Find the stream cross-sectional area in square ft (ft²).

In a straight section of stream, measure the width at the water's surface and bottom channel. For averaged depth, take measurements at one-foot intervals and divide by the number of readings.

(W^s + W^b) ÷ 2 × D = Area:

$$\frac{\text{_____ ft} + \text{_____ ft}}{\text{surface bottom}} \div 2 = \text{_____ ft} \div 2 = \text{_____ ft.} \times \text{_____ ft} = \text{_____ ft}^2$$

ave.width depth area (sq. ft.)

Step 3: Find the rate of flow in cubic feet per second (cfs).

Velocity [step 1] × area [step 2] = rate OR _____ f/s × _____ ft² = _____ cfs

velocity area (sq. ft.) rate

Estimating Stream Load of Soil Sediment: lbs/day

Step 4: Convert total suspended solids reading to pounds of sediment per day (lbs/day)

IV. Sediment Load

_____ lbs/day TSS reading × conversion factor × rate (cfs) [step 3] = pounds per day

OR

$$\frac{\text{_____ turbidity}}{\text{_____}} \times 5.39 = \text{_____} \times \frac{\text{_____ cfs}}{\text{_____ rate}} = \text{_____ load lbs/day}$$

Dissolved Oxygen

What is dissolved oxygen and why is it important?

The stream system both produces and consumes oxygen. It gains oxygen from the atmosphere and from plants as a result of photosynthesis. Running water, because of its churning, dissolves more oxygen than still water, such as that in a reservoir behind a dam. Respiration by aquatic animals, decomposition, and various chemical reactions consume oxygen.

Wastewater from sewage treatment plants often contains organic materials that are decomposed by microorganisms, which use oxygen in the process. (The amount of oxygen consumed by these organisms in breaking down the waste is known as the biochemical oxygen demand or BOD. A discussion of BOD and how to monitor it is included at the end of this section.) Other sources of oxygen-consuming waste include stormwater runoff from farmland or urban streets, feedlots, and failing septic systems.

Oxygen is measured in its dissolved form as dissolved oxygen (DO). If more oxygen is consumed than is produced, dissolved oxygen levels decline and some sensitive animals may move away, weaken, or die.

DO levels fluctuate seasonally and over a 24-hour period. They vary with water temperature and altitude. Cold water holds more oxygen than warm water (Table 5.3) and water holds less oxygen at higher altitudes. Thermal discharges, such as water used to cool machinery in a manufacturing plant or a power plant, raise the temperature of water and lower its oxygen content. Aquatic animals are most vulnerable to lowered DO levels in the early morning on hot summer days when stream flows are low, water temperatures are high, and aquatic plants have not been producing oxygen since sunset.

| Temperature (°C) | DO (mg/l) | Temperature (°C) | DO (mg/l) | Table 5.3 Maximum dissolved oxygen concentrates vary with temperature |
|------------------|-----------|------------------|-----------|--|
| 0 | 14.60 | 23 | 8.56 | |
| 1 | 14.19 | 24 | 8.40 | |
| 2 | 13.81 | 25 | 8.24 | |
| 3 | 13.44 | 26 | 8.09 | |
| 4 | 13.09 | 27 | 7.95 | |
| 5 | 12.75 | 28 | 7.81 | |
| 6 | 12.43 | 29 | 7.67 | |
| 7 | 12.12 | 30 | 7.54 | |
| 8 | 11.83 | 31 | 7.41 | |
| 9 | 11.55 | 32 | 7.28 | |
| 10 | 11.27 | 33 | 7.16 | |
| 11 | 11.01 | 34 | 7.16 | |
| 12 | 10.76 | 35 | 6.93 | |
| 13 | 10.52 | 36 | 6.82 | |
| 14 | 10.29 | 37 | 6.71 | |
| 15 | 10.07 | 38 | 6.61 | |
| 16 | 9.85 | 39 | 6.51 | |
| 17 | 9.65 | 40 | 6.41 | |
| 18 | 9.45 | 41 | 6.41 | |
| 19 | 9.26 | 42 | 6.22 | |
| 20 | 9.07 | 43 | 6.13 | |
| 21 | 8.90 | 44 | 6.04 | |
| 22 | 8.72 | 45 | 5.95 | |

Sampling and Equipment Considerations

In contrast to lakes, where DO levels are most likely to vary vertically in the water column, the DO in rivers and streams changes more horizontally along the course of the waterway. This is especially true in smaller, shallower streams. In larger, deeper rivers, some vertical stratification of dissolved oxygen might occur. The DO levels in and below riffle areas, waterfalls, or dam spillways are typically higher than those in pools and slower-moving stretches. If you wanted to measure the effect of a dam, it would be important to sample for DO behind the dam, immediately below the spillway, and upstream of the dam. Since DO levels are critical to fish, a good place to sample is in the pools that fish tend to favor or in the spawning areas they use.

An hourly time profile of DO levels at a sampling site is a valuable set of data because it shows the change in DO levels from the low point just before sunrise to the high point sometime in the midday. However, this might not be practical for a volunteer monitoring program. It is important to note the time of your DO sampling to help judge when in the daily cycle the data were collected.

DO is measured either in milligrams per liter (mg/L) or "percent saturation." Milligrams per liter is the amount of oxygen in a liter of water. Percent saturation is the amount of oxygen in a liter of water relative to the total amount of oxygen that the water can hold at that temperature.

DO samples are collected using a special BOD bottle: a glass bottle with a "turtleneck" and a ground glass stopper. You can fill the bottle directly in the stream if the stream is wadable or boatable, or you can use a sampler that is dropped from a bridge or boat into water deep enough to submerge the sampler. Samplers can be made or purchased. Dissolved oxygen is measured primarily either by using some variation of the Winkler method or by using a meter and probe.

Winkler Method

The Winkler method involves filling a sample bottle completely with water (no air is left to bias the test). The dissolved oxygen is then "fixed" using a series of reagents that form an acid compound that is titrated. Titration involves the drop-by-drop addition of a reagent that neutralizes the acid compound and causes a change in the color of the solution. The point at which the color changes is the "endpoint" and is equivalent to the amount of oxygen dissolved in the sample. The sample is usually fixed and titrated in the field at the sample site. It is possible, however, to prepare the sample in the field and deliver it to a lab for titration.

If your program requires a high degree of accuracy and precision in DO results, use a digital titrator. A kit that uses an eye dropper-type or syringe-type titrator is suitable for most other purposes. The lower cost of this type of DO field kit might be attractive if you are relying on several teams of volunteers to sample multiple sites at the same time.

How to collect and analyze samples

The procedures for collecting and analyzing samples for dissolved oxygen consist of the following tasks:

TASK 1 Prepare before leaving for the sampling site

Refer to [section 2.3 - Safety Considerations](#) for details on confirming sampling date and time, safety considerations, checking supplies, and checking weather and directions. In addition to the standard sampling equipment and apparel, when sampling for dissolved oxygen, include the following equipment:

If Using the Winkler Method

- Field kit and instructions for DO testing
- Enough reagents for the number of sites to be tested
- Kemmerer, Van Dorn, or home-made sampler to collect deep-water samples
- Data sheet for dissolved oxygen to record results

TASK 2 Confirm that you are at the proper location

The directions for sampling should provide specific information about the exact point in the stream from which you are to sample; e.g., "approximately 6 feet out from the large boulder downstream from the west side of the bridge." If you are not sure you are in the exact spot, record a detailed description of where you took the sample so that it can be compared to the actual site later.

TASK 3 Collect samples and fill out the field data sheet

Winkler Method

Use a BOD bottle to collect the water sample. The most common sizes are 300 milliliters (mL) and 60 mL. Be sure that you are using the correct volume for the titration method that will be used to determine the amount of DO. There is usually a white label area on the bottle, and this may already be numbered. If so, be sure to record that number on the field data sheet. If your bottle is not already numbered, place a label on the bottle (not on the cap because a cap can be inadvertently placed on a different bottle) and use a waterproof marker to write in the site number.

If you are collecting duplicate samples, label the duplicate bottle with the correct code, which should be determined prior to sampling by the lab supplying the bottles. Use the following procedure for collecting a sample for titration by the Winkler method:

1. Remember that the water sample must be collected in such a way that you can cap the bottle while it is still submerged. That means that you must be able to reach into the water with both arms and the water must be deeper than the sample bottle.
2. Carefully wade into the stream. Stand so that you are facing one of the banks.

3. Collect the sample so that you are not standing upstream of the bottle. Remove the cap of the BOD bottle. Slowly lower the bottle into the water, pointing it downstream, until the lower lip of the opening is just submerged. Allow the water to fill the bottle very gradually, avoiding any turbulence (which would add oxygen to the sample). When the water level in the bottle has stabilized (it won't be full because the bottle is tilted), slowly turn the bottle upright and fill it completely. Keep the bottle under water and allow it to overflow for 2 or 3 minutes to ensure that no air bubbles are trapped.
4. Cap the bottle while it is still submerged. Lift it out of the water and look around the "collar" of the bottle just below the bottom of the stopper. If you see an air bubble, pour out the sample and try again.
5. "Fix" the sample immediately following the directions in your kit:
 - o Remove the stopper and add the fixing reagents to the sample.
 - o Immediately insert the stopper so air is not trapped in the bottle and invert several times to mix. This solution is caustic. Rinse your hands if you get any solution on them. An orange-brown flocculent precipitate will form if oxygen is present.
 - o Wait a few minutes until the floc in the solution has settled. Again invert the bottle several times and wait until the floc has settled. This ensures complete reaction of the sample and reagents. The sample is now fixed, and atmospheric oxygen can no longer affect it. If you are taking the sample to the lab for titration, no further action is necessary. You can store the sample in a cooler for up to 8 hours before titrating it in a lab. If you are titrating the sample in the field, see *Task 4: Analyze the Samples*.

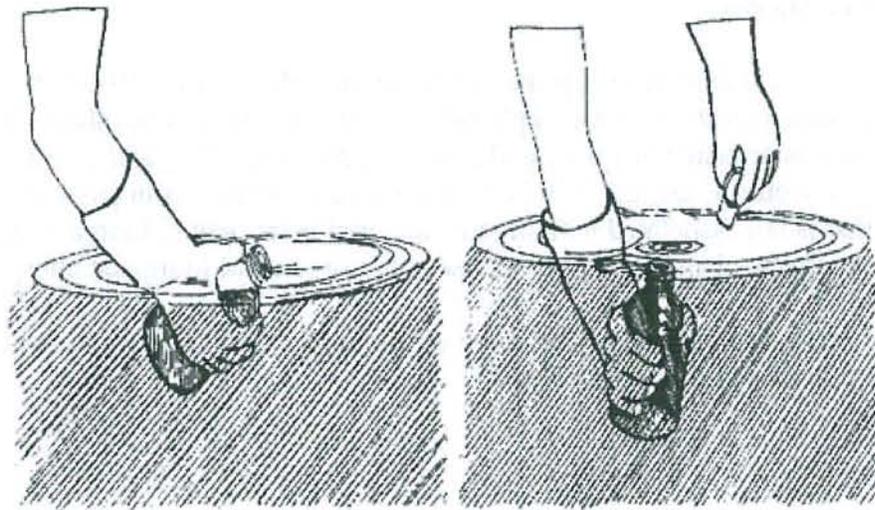


Figure 5.7

Taking a water sample for DO analysis

Point the bottle downstream and fill gradually. Cap underwater when full.

References

APHA. 1992. *Standard methods for the examination of water and wastewater*. 18th ed. American Public Health Association, Washington, DC.

Phosphorus

Why is phosphorus important?

Both phosphorus and nitrogen are essential nutrients for the plants and animals that make up the aquatic food web. Since phosphorus is the nutrient in short supply in most fresh waters, even a modest increase in phosphorus can, under the right conditions, set off a whole chain of undesirable events in a stream including accelerated plant growth, algae blooms, low dissolved oxygen, and the death of certain fish, invertebrates, and other aquatic animals.

There are many sources of phosphorus, both natural and human. These include soil and rocks, wastewater treatment plants, runoff from fertilized lawns and cropland, failing septic systems, runoff from animal manure storage areas, disturbed land areas, drained wetlands, water treatment, and commercial cleaning preparations.

Forms of phosphorus

Phosphorus has a complicated story. Pure, "elemental" phosphorus (P) is rare. In nature, phosphorus usually exists as part of a phosphate molecule (PO₄). Phosphorus in aquatic systems occurs as organic phosphate and inorganic phosphate. Organic phosphate consists of a phosphate molecule associated with a carbon-based molecule, as in plant or animal tissue. Phosphate that is not associated with organic material is inorganic. Inorganic phosphorus is the form required by plants. Animals can use either organic or inorganic phosphate.

Both organic and inorganic phosphorus can either be dissolved in the water or suspended (attached to particles in the water column).

The phosphorus cycle

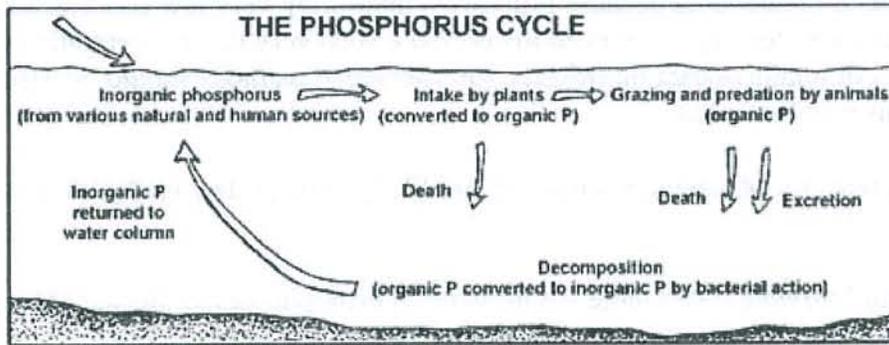


Figure 5.12

The phosphorus cycle

Phosphorus changes form as it cycles through the aquatic environment.

Phosphorus cycles through the environment, changing form as it does so (Fig. 5.12). Aquatic plants take in dissolved inorganic phosphorus and convert it to organic phosphorus as it becomes part of their tissues. Animals get the organic phosphorus they need by eating either aquatic plants, other animals, or decomposing plant and animal material.

As plants and animals excrete wastes or die, the organic phosphorus they contain sinks to the bottom, where bacterial decomposition converts it back to inorganic phosphorus, both dissolved and attached to particles. This inorganic phosphorus gets back into the water column when the bottom is stirred up by animals, human activity, chemical interactions, or water currents. Then it is taken up by plants and the cycle begins again.

In a stream system, the phosphorus cycle tends to move phosphorus downstream as the current carries decomposing plant and animal tissue and dissolved phosphorus. It becomes stationary only when it is taken up by plants or is bound to particles that settle to the bottom of pools.

In the field of water quality chemistry, phosphorus is described using several terms. Some of these terms are chemistry based (referring to chemically based compounds), and others are methods-based (they describe what is measured by a particular method).

The term "orthophosphate" is a chemistry-based term that refers to the phosphate molecule all by itself. "Reactive phosphorus" is a corresponding method-based term that describes what you are actually measuring when you perform the test for orthophosphate. Because the lab procedure isn't quite perfect, you get mostly orthophosphate but you also get a small fraction of some other forms.

More complex inorganic phosphate compounds are referred to as "condensed phosphates" or "polyphosphates." The method-based term for these forms is "acid hydrolyzable."

Monitoring phosphorus

Monitoring phosphorus is challenging because it involves measuring very low concentrations down to 0.01 milligram per liter (mg/L) or even lower. Even such very low concentrations of phosphorus can have a dramatic impact on streams. Less sensitive methods should be used only to identify serious problem areas.

While there are many tests for phosphorus, only four are likely to be performed by volunteer monitors.

1. The *total orthophosphate* test is largely a measure of orthophosphate. Because the sample is not filtered, the procedure measures both dissolved and suspended orthophosphate. The EPA-approved method for measuring total orthophosphate is known as the ascorbic acid method. Briefly, a reagent (either liquid or powder) containing ascorbic acid and ammonium molybdate reacts with orthophosphate in the sample to form a blue compound. The intensity of the blue color is directly proportional to the amount of orthophosphate in the water.
2. The *total phosphorus* test measures all the forms of phosphorus in the sample (orthophosphate, condensed phosphate, and organic phosphate). This is accomplished by first "digesting" (heating and acidifying) the sample to convert all the other forms to orthophosphate. Then the orthophosphate is measured by the ascorbic acid method. Because the sample is not filtered, the procedure measures both dissolved and suspended orthophosphate.
3. The *dissolved phosphorus* test measures that fraction of the total phosphorus which is in solution in the water (as opposed to being attached to suspended particles). It is determined by first filtering the sample, then analyzing the filtered sample for total phosphorus.
4. *Insoluble phosphorus* is calculated by subtracting the dissolved phosphorus result from the total phosphorus result.

All these tests have one thing in common they all depend on measuring orthophosphate. The total orthophosphate test measures the orthophosphate that is already present in the sample. The others measure that which is already present and that which is formed when the other forms of phosphorus are converted to orthophosphate by digestion.

Nitrates

What are nitrates and why are they important?

Nitrates are a form of nitrogen, which is found in several different forms in terrestrial and aquatic ecosystems. These forms of nitrogen include ammonia (NH₃), nitrates (NO₃), and nitrites (NO₂). Nitrates are essential plant nutrients, but in excess amounts they can cause significant water quality problems. Together with phosphorus, nitrates in excess amounts can

accelerate eutrophication, causing dramatic increases in aquatic plant growth and changes in the types of plants and animals that live in the stream. This, in turn, affects dissolved oxygen, temperature, and other indicators. Excess nitrates can cause hypoxia (low levels of dissolved oxygen) and can become toxic to warm-blooded animals at higher concentrations (10 mg/L or higher) under certain conditions. The natural level of ammonia or nitrate in surface water is typically low (less than 1 mg/L); in the effluent of wastewater treatment plants, it can range up to 30 mg/L.

Sources of nitrates include wastewater treatment plants, runoff from fertilized lawns and cropland, failing on-site septic systems, runoff from animal manure storage areas, and industrial discharges that contain corrosion inhibitors.

How to collect and analyze samples

The field procedures for collecting and analyzing samples for phosphorus, nitrates, and ammonia consist of the following tasks:

General preparation and sampling considerations

The sections that follow will detail specific sampling and equipment considerations and analytical procedures for each of the most common water quality parameters. There are, however, two general tasks that are accomplished anytime water samples are taken. These are discussed below.

Task 1 Preparation of Sampling Containers

Reused sample containers and glassware must be cleaned and rinsed before the first sampling run and after each run by following either Method A or Method B described below. The most suitable method depends on the parameter being measured.

Method A: General Preparation of Sampling Containers

The following method should be used when preparing all sample containers and glassware for monitoring conductivity, total solids, turbidity, pH, and total alkalinity. Wear latex gloves!

1. Wash each sample bottle or piece of glassware with a brush and phosphate-free detergent.
2. Rinse three times with cold tap water.
3. Rinse three times with distilled or deionized water.

Method B: Acid Wash Procedure for Preparing Sampling Containers

This method should be used when preparing all sample containers and glassware for monitoring nitrates and phosphorus. Wear latex gloves!

1. Wash each sample bottle or piece of glassware with a brush and phosphate-free detergent.
2. Rinse three times with cold tap water.
3. Rinse with 10 percent hydrochloric acid.
4. Rinse three times with deionized water.

Task 2 Collecting Samples

In general, sample away from the streambank in the main current. Never sample stagnant water. The outside curve of the stream is often a good place to sample, since the main current tends to hug this bank. In shallow stretches, carefully wade into the center current to collect the sample.

A boat will be required for deep sites. Try to maneuver the boat into the center of the main current to collect the water sample.

When collecting a water sample for analysis in the field or at the lab, follow the steps below.

For Screw-cap Bottles

To collect water samples using screw-cap sample bottles, use the following procedures (Fig. 5.2 and 5.3):



Figure 5.2

Getting into position to take a water sample

Volunteers should sample in the main current, facing upstream.

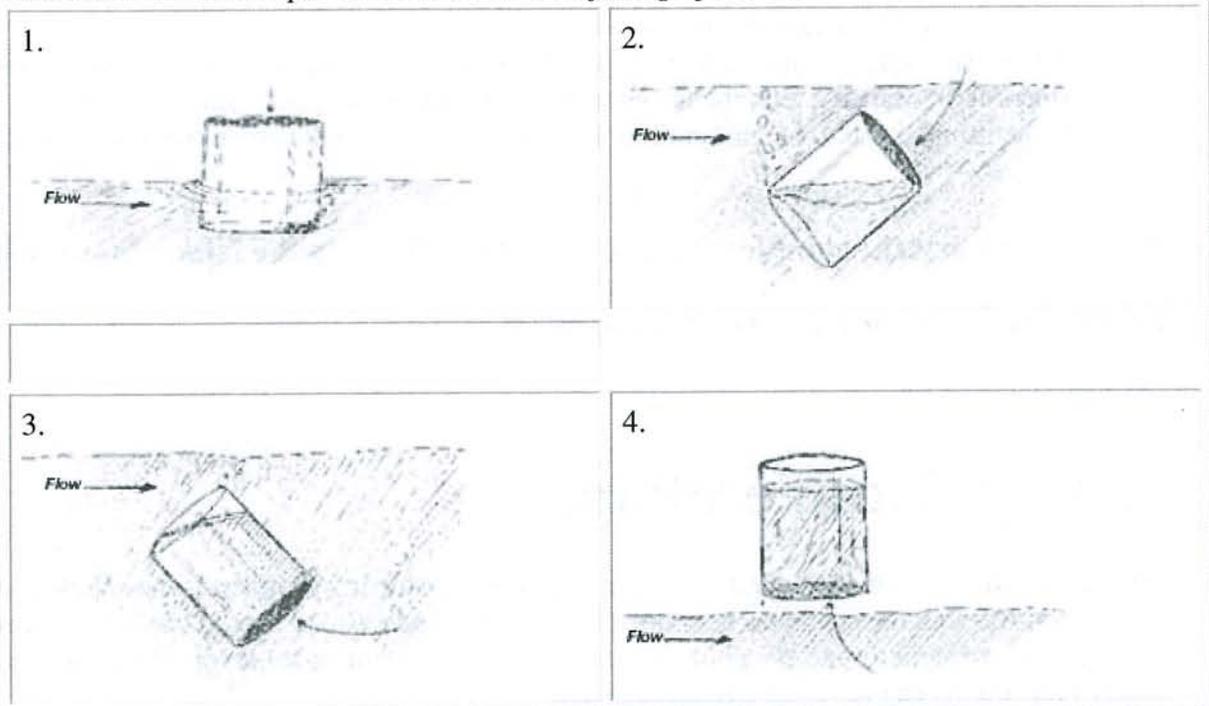


Figure 5.3

Taking a water sample

Turn the bottle into the current and scoop in an upstream direction.

1. Label the bottle with the site number, date, and time.
2. Remove the cap from the bottle just before sampling. Avoid touching the inside of the bottle or the cap. If you accidentally touch the inside of the bottle, use another one.
3. *Wading.* Try to disturb as little bottom sediment as possible. In any case, be careful not to collect water that has sediment from bottom disturbance. Stand facing upstream. Collect the water sample on your upstream side, in front of you. You may also tape your bottle to an extension pole to sample from deeper water.
Boat. Carefully reach over the side and collect the water sample on the upstream side of the boat.
4. Hold the bottle near its base and plunge it (opening downward) below the water surface. If you are using an extension pole, remove the cap, turn the bottle upside down, and plunge it into the water, facing upstream. Collect a water sample 8 to 12 inches beneath the surface or mid-way between the surface and the bottom if the stream reach is shallow.
5. Turn the bottle underwater into the current and away from you. In slow-moving stream reaches, push the bottle underneath the surface and away from you in an upstream direction.

6. Leave a 1-inch air space (Except for DO and BOD samples). Do not fill the bottle completely (so that the sample can be shaken just before analysis). Recap the bottle carefully, remembering not to touch the inside.
7. Fill in the bottle number and/or site number on the appropriate field data sheet. This is important because it tells the lab coordinator which bottle goes with which site.
8. If the samples are to be analyzed in the lab, place them in the cooler for transport to the lab.

TASK 5 Return the samples and the field data sheets to the lab/drop-off point

Deliver your samples and field data sheets to the lab.

Safety Considerations

One of the most critical considerations for a volunteer monitoring program is the safety of its volunteers. All volunteers should be trained in safety procedures and should carry with them a set of safety instructions and the phone number of their program coordinator or team leader. Safety precautions can never be overemphasized.

The following are some basic common sense safety rules. At the site:

- Always monitor with at least one partner. Always let someone else know where you are, when you intend to return, and what to do if you don't come back at the appointed time.
- Develop a safety plan. Find out the location and telephone number of the nearest telephone and write it down. Locate the nearest medical center and write down directions on how to get between the center and your site(s) so that you can direct emergency personnel. Have each member of the sampling team complete a medical form that includes emergency contacts, insurance information, and pertinent health information such as allergies, diabetes, epilepsy, etc.
- Have a first aid kit handy (see box below). Know any important medical conditions of team members (e.g., heart conditions or allergic reactions to bee stings). It is best if at least one team member has first aid/CPR training.
- Listen to weather reports. Never go sampling if severe weather is predicted or if a storm occurs while at the site.
- Never wade in swift or high water. Do not monitor if the stream is at flood stage.
- If you drive, park in a safe location. Be sure your car doesn't pose a hazard to other drivers and that you don't block traffic.
- Put your wallet and keys in a safe place, such as a watertight bag you keep in a pouch strapped to your waist. Without proper precautions, wallet and keys might end up downstream.
- Never cross private property without the permission of the landowner. Better yet, sample only at public access points such as bridge or road crossings or public parks. Take along a card identifying you as a volunteer monitor.

- Confirm that you are at the proper site location by checking maps, site descriptions, or directions.
- Watch for irate dogs, farm animals, wildlife (particularly snakes), and insects such as ticks, hornets, and wasps. Know what to do if you get bitten or stung.
- Watch for poison ivy, poison oak, sumac, and other types of vegetation in your area that can cause rashes and irritation.
- Never drink the water in a stream. Assume it is unsafe to drink, and bring your own water from home. After monitoring, wash your hands with antibacterial soap.
- Do not monitor if the stream is posted as unsafe for body contact. If the water appears to be severely polluted, contact your program coordinator.
- Do not walk on unstable stream banks. Disturbing these banks can accelerate erosion and might prove dangerous if a bank collapses. Disturb streamside vegetation as little as possible.
- Be very careful when walking in the stream itself. Rocky-bottom streams can be very slippery and can contain deep pools; muddy-bottom streams might also prove treacherous in areas where mud, silt, or sand have accumulated in sink holes. If you must cross the stream, use a walking stick to steady yourself and to probe for deep water or muck. Your partner(s) should wait on dry land ready to assist you if you fall. Do not attempt to cross streams that are swift and above the knee in depth. Wear waders and rubber gloves in streams suspected of having significant pollution problems.
- If you are sampling from a bridge, be wary of passing traffic. Never lean over bridge rails unless you are firmly anchored to the ground or the bridge with good hand/foot holds.
- **If at any time you feel uncomfortable about the condition of the stream or your surroundings, stop monitoring and leave the site at once. Your safety is more important than the data!**

When using chemicals:

- Know your equipment, sampling instructions, and procedures before going out into the field. Prepare labels and clean equipment before you get started.
- Keep all equipment and chemicals away from small children. Many of the chemicals used in monitoring are poisonous. Tape the phone number of the local poison control center to your sampling kit.
- Avoid contact between chemical reagents and skin, eye, nose, and mouth. Never use your fingers to stopper a sample bottle (e.g., when you are shaking a solution). Wear safety goggles when performing any chemical test or handling preservatives.
- Know chemical cleanup and disposal procedures. Wipe up all spills when they occur. Return all unused chemicals to your program coordinator for safe disposal. Close all containers tightly after use. Do not switch caps.
- Know how to use and store chemicals. Do not expose chemicals or equipment to temperature extremes or long term direct sunshine.

Firelands Coastal Tributaries Watershed Program

Tribs Team Volunteer Stream Monitors

Volunteer Commitment

I, _____, adopt the _____ Creek,
Monitoring Site Location(s) _____
on _____ (date) for a duration of _____ years (min. of 1 year).

I will do the following :

- _____ Training for monitoring techniques (required)
- _____ Chemical Test monitoring once per month
- _____ Other monitoring techniques (list) _____ grab sampling

If I am unable to complete my monitoring commitment, I will notify the Erie Soil and Water Conservation District (419-626-5211).

Signature

Organization _____

Address: _____

City, State, Zip _____

Telephone # _____

Email _____

Firelands Coastal Tributaries Watershed Program

Tribs Team Stream Monitoring Equipment Check List

- Carrying Case
 - Temperature Pocket Pal
 - pH Pocket Pal
 - Screwdriver
 - DO Kit
 - Glass mixing bottle
 - Plastic tube
 - Glass square mixing bottle
 - Sodium thiosulfate standard solution
 - Dissolved oxygen 1 reagent
 - Dissolved oxygen 2 reagent
 - Dissolved oxygen 3 reagent
 - Nail clippers
 - DI Water Rinse Bottle
 - pH 7.0 buffer solution
 - pH 10.0 buffer solution
 - First Aid Kit
 - Instruction Sheets

- Bucket
 - Sampling Bottles
 - Waste Bottle
 - Ohio Sediment Stick (Turbidity Tube)
 - Rope
 - Small Bucket
 - Clip Board
 - Data Sheets

Chemical Sampling Protocol for Old Woman Creek Watershed Volunteers

Preparation

- Collect sampling basket from OWC Visitor Center.
 - Check basket to insure that all gear is included. If not, speak to staff at OWC: Marje Bernhardt, Dr. Klarer
 1. Dissolved oxygen test kit
 2. pH buffers labeled 7 and 10
 3. Meters for Temperature and for pH
 4. 2 Bottles per site (one 250ml and one 100ml) for lab chemical analysis
 5. Data sheet and pencils
 6. Manual for procedures to determine dissolved oxygen

At sampling site

- Choose safe parking site
- Lower bucket and get water sample just to rinse out the bucket
 - Discard sample onto the shore away from the creek

Bucket sample: Step 1

- Measure and record the **pH readings** of the pH 7.0 and pH 10.0 buffers in kit onto data sheet
- Lower bucket and collect water sample for field and lab analysis
- Determine **temperature** and **pH** values of the sample with meters provided; then record data on data sheet.

Bucket sample: Step 2

- Carefully collect sample for **dissolved oxygen** as demonstrated in training
- Immediately add powder pillows 1 and 2 to dissolved oxygen sample; shake bottle; and set aside to allow the precipitate to settle to the bottom of bottle.

Bucket sample: Step 3

- Rinse the two chemical analysis sample bottles with a little water from the bucket
- Fill both bottles from the same water in the bucket, for lab analysis
 - Write date and time of collection on these 2 bottles for lab analysis
 - Discard remaining water in the bucket

Bucket sample: Step 4

- Follow instructions for **turbidity** measurement using Ohio Sediment Stick.
 - Record data on data sheet.

Step 4: Final field preparation of dissolved oxygen sample (from Step 2)

- Add powder pillow #3 to **dissolved oxygen sample**, making sure not to lose any of the precipitate
- Shake. The sample is now stable. Finish DO test as directed in Hach Kit instructions.

Final Steps at sampling site

- Finish filling out data sheet noting anything unusual observed at this site
- Travel to next sampling site.

After finishing sampling of assigned sites

- Make sure meters are turned off
- Return sampling basket and collected water samples for lab analysis to OWC Visitor Center. (If you are unable to return the sample during business hours please refrigerate samples and return them within 24 hours.)
- Check to insure all gear is included in sampling basket before checking in at OWC.

We appreciate your interest and effort in this watershed monitoring program.

Chemical Sampling Protocol for Pipe Creek Watershed Volunteers

Preparation

- Collect sampling basket from Erie SWCD.
 - Check basket to insure that all gear is included. If not, speak to staff at ESWCD.
 1. Dissolved oxygen test kit
 2. pH buffers labeled 7 and 10
 3. Meters for Temperature and for pH
 4. 2 Bottles per site (one 250ml and one 100ml) for lab chemical analysis
 5. Data sheet and pencils
 6. Manual for procedures to determine dissolved oxygen

At sampling site

- Choose safe parking site
- Lower bucket and get water sample just to rinse out the bucket
 - Discard sample onto the shore away from the creek

Bucket sample: Step 1

- Measure and record the **pH readings** of the pH 7.0 and pH 10.0 buffers in kit onto data sheet
- Lower bucket and collect water sample for field and lab analysis
- Determine **temperature** and **pH** values of the sample with meters provided; then record data on data sheet.

Bucket sample: Step 2

- Carefully collect sample for **dissolved oxygen** as demonstrated in training
- Immediately add powder pillows 1 and 2 to dissolved oxygen sample; shake bottle; and set aside to allow the precipitate to settle to the bottom of bottle.

Bucket sample: Step 3

- Rinse the two chemical analysis sample bottles with a little water from the bucket
- Fill both bottles from the same water in the bucket, for lab analysis
 - Write date and time of collection on these 2 bottles for lab analysis
 - Discard remaining water in the bucket

Bucket sample: Step 4

- Follow instructions for **turbidity** measurement using Ohio Sediment Stick.
 - Record data on data sheet.

Step 4: Final field preparation of dissolved oxygen sample (from Step 2)

- Add powder pillow #3 to **dissolved oxygen sample**, making sure not to lose any of the precipitate
- Shake. The sample is now stable. Finish DO test as directed in Hach Kit instructions.

Final Steps at sampling site

- Finish filling out data sheet noting anything unusual observed at this site
- Travel to next sampling site.

After finishing sampling of assigned sites

- Make sure meters are turned off
- Return sampling basket and collected water samples for lab analysis to Sandusky Waste Water Treatment Plant. (If you are unable to return the sample during business hours please refrigerate samples and return them within 24 hours.)
- Check to insure all gear is included in sampling basket before checking in at ESWCD.

We appreciate your interest and effort in this watershed monitoring program.

Water Quality Sampling Data Sheet

Stream Code: _____ Watershed Name: _____
 Monitors _____
 Date: ____/____/____ Time: _____ Temp: _____

| Weather in the past 24 hours | | Weather now | |
|------------------------------|--|-----------------------------|--|
| Storm (heavy rain) | | Storm (heavy rain) | |
| Rain (steady rain) | | Rain (steady rain) | |
| Showers (intermittent rain) | | Showers (intermittent rain) | |
| Overcast | | Overcast | |
| Clear/Sunny | | Clear/Sunny | |

FIELD USE ONLY

Water Sample Temperature _____ °C
 pH reading in buffer 7.0 _____ buffer 10.0 _____
 Water sample pH _____
 DO _____ drops _____ mg/L
 Turbidity _____ in _____ (TSS)mg/L

LAB USE ONLY

Date Received _____ Date Analyzed _____

| Sample # | Parameter | Unit |
|----------|--------------|------|
| | SRP | µg/L |
| | NH3 | mg/L |
| | Nitrate | mg/L |
| | Conductivity | mg/L |
| | Turbidity | NTU |

Comments:

Dissolved Oxygen Calculation

mg/L Dissolved Oxygen = number of drops x 0.2

Number of drops _____ x 0.2 = _____ mg/L

Contacts:

- Breann Hohman (Watershed Coordinator)
419-626-5211
- Dr. Dave Klarer (Old Woman Creek)
419-433-4601
- Barry Riddle (Pipe Creek)
419-626-5703

Laboratory Locations and Drop-Off Times

- Old Woman Creek Reserve**
8:00am-5:00pm
2514 East Cleveland Rd.
Huron, OH 44839
Contact: Dr. David Klarer
419-433-4601
- Sandusky Waste Water Treatment Plant**
7:00am-4:00pm or 6:00pm-8:00pm
304 Harrison St.
Sandusky, OH 44870
Contact: Richard Sinwald
419-627-5750

Use this table to convert Stick readings to an estimate of the weight of solids suspended in the water column. Table is based on research by Anderson and Davic, 2001, in preparation.

Estimating Total Suspended Solids: TSS

| I. Total Suspended Solids: TSS (Turbidity) | Stick(in) TSS(mg/l) | Stick(in) TSS(mg/l) | Stick(in) TSS(mg/l) | Stick(in) TSS(mg/l) |
|--|---------------------|---------------------|---------------------|---------------------|
| 0.5 | 1751.2 | 10.0 | 33.7 | 24.0 |
| 1.0 | 701.9 | 11.0 | 29.7 | 25.0 |
| 1.5 | 411.2 | 12.0 | 26.5 | 26.0 |
| 2.0 | 281.4 | 13.0 | 23.8 | 27.0 |
| 2.5 | 209.6 | 14.0 | 21.6 | 28.0 |
| 3.0 | 164.8 | 15.0 | 19.7 | 29.0 |
| 3.5 | 134.5 | 16.0 | 18.1 | 30.0 |
| 4.0 | 112.8 | 17.0 | 16.7 | 31.0 |
| 4.5 | 96.6 | 18.0 | 15.5 | 32.0 |
| 5.0 | 84.0 | 19.0 | 14.4 | 33.0 |
| 6.0 | 66.1 | 20.0 | 13.5 | 34.0 |
| 7.0 | 53.9 | 21.0 | 12.7 | 35.0 |
| 8.0 | 45.2 | 22.0 | 11.9 | ≥ 36.0 |
| 9.0 | 38.7 | 23.0 | 11.2 | < 5.0 |

II. Water Quality This scale is based on Ohio statewide reference site data published by Brown, 1988.

- Excellent TSS < 10mg/l = excellent water quality
- Normal TSS 10-28mg/l = normal water quality
- Impaired TSS 29-133mg/l = impaired stream
- Severely Impaired TSS > 133mg/l = severely impacted stream

**RELEASE AND WAIVER OF LIABILITY,
ASSUMPTION OF RISK, AND INDEMNITY AGREEMENT**

IN CONSIDERATION of being permitted to participate with the Firelands Coastal Tributaries Watershed Program "Tribes Team" Volunteer Stream Monitoring of Old Woman Creek and Pipe Creek Watershed between the months of September 2007 and May of 2008.

I, for myself, for personal representatives, assigns, heirs, and next of kin:

1. ACKNOWLEDGE, agree, and represent that I understand the nature of the Stream monitoring activities and that I am qualified, in good health, and in proper physical condition to participate in such Activity. I further agree and warrant that if at any time I believe conditions to be unsafe, I will immediately discontinue further participation in that Activity.
2. FULLY UNDERSTAND: (a) Stream monitoring activities involves risks and dangers; (b) these risks and dangers may be caused by my own actions or inactions, the actions or inactions of others participating in the Activity, or the conditions in which the Activity takes place; (c) and fully accept and assume all such risks and all responsibilities for injuries I incur as a result of my participation in the Activity.
3. HEREBY RELEASE, DISCHARGE, AND HOLD HARMLESS the Firelands Coastal Tributaries Watershed Program Partners, their respective administrators, directors, officers, and employees, other participants, any sponsors, advertisers, and owner and lessors of the premises on which the stream monitoring activity takes place, (each considered one of the "Releasees" herein) from all liability, claims, or damages on my account caused or alleged to be caused by the negligence of the "Releasees".

I have read this agreement, fully understand its terms, understand that I have given up substantial rights by signing it and have signed it freely and without inducement or assurance of any nature.

Printed Name of Participant _____

Address:

Phone: _____

Participant's Signature (if age 18 or over): _____

Date: _____

Signature of Parent or Guardian of Participant if under the age of 18:

Appendix B

Laboratory Operating Standards

OLD WOMAN CREEK STANDARD OPERATING PROCEDURES AND QUALITY CONTROL GUIDELINES



Prepared 2001 (rev 2003)

Standard Operating Procedures- Water Chemistry Old Woman Creek

Purpose

The purpose of this document is to provide a written record of the procedures and reagents used in the Old Woman Creek water chemistry program and also to insure that the chemical analysis conducted at Old Woman Creek is of the highest quality and meets or exceeds accepted quality control standards.

Sample Bottle and Glassware Cleaning

Sample bottles are rinsed six (6) times with distilled water and then rinsed once with sample water. Store bottles upside down uncapped to allow the bottles to dry. On alternate weeks the bottles are acid washed with 10% HCl and then rinsed six (6) times with distilled water. It may be necessary to acid wash sample bottles weekly if analysis or bottle blanks indicate contamination.

All glass- and plastic-ware that is to be used in either chemical analysis or chlorophyll analysis is also rinsed in 10% hydrochloric acid and then rinsed at least 6 times in distilled water. The glassware used for chlorophyll analysis is normally rinsed a minimum of 8 times in distilled water.

Sample Volume

Chemical analysis for each site sample at OWC requires approximately 1000 ml of sample water.

Sampling

Rinse the sample bottle three times before collecting a 1-liter sample. Fill the bottle completely and cap. Store in the dark (and put on ice if unable to begin chemistry within several hours). Temperature, dissolved oxygen, and pH are taken at the site at time of sampling. (Meters should be turned on at least 15 minutes before calibration. The field meters should be calibrated just prior to first reading. They should not be turned off between readings.) At data logger sites, the water sample is collected before the data loggers are swapped to insure that relatively undisturbed water is collected for analysis.

Laboratory Analysis

Upon returning to the laboratory, each bottle is shaken and a 100 ml sub-sample for total P and metals (stored in a plastic bottle and preserved with 1 ml 10% HCl) and a 25 ml sub-sample for alkalinity determination are removed. Also prior to filtering, turbidity and conductivity are determined using laboratory meters. Samples for chemical analysis are filtered as quickly as possible using an aspirator/vacuum system. Samples for chlorophyll analysis are filtered first.

Filtration

All samples are filtered prior to chemical analysis. An aspirator/vacuum system is to be used to prevent cell breakage.

Samples for chemical analysis are first filtered through 9 cm diameter GF/C glass-fiber paper. After pouring the sample into the filter apparatus, the collecting bottle is rinsed 6 times with distilled water and then briefly shaken dry. The filtrate is then poured back into the sampling bottle, and the filter flask is rinsed 6 times with distilled water and briefly shaken dry. The water is then filtered through a 47 mm diameter membrane filter (.45 micron) that has been soaked in two rinses of distilled water for a minimum of 24 hours each rinse. After pouring this sample into the filter apparatus the sample bottle is again rinsed 6 times in distilled water and briefly shaken dry. The filtrate is then poured back into the sample bottle and the filter apparatus is again rinsed 6 times in distilled water in preparation for the next sample. At the end of the filtering process, the filter apparatus is rinsed in 10% HCl and then rinsed at least six times in distilled water and stored upside down until next use.

Chemical Analysis

General Considerations

All chemicals used in making reagents are at least certified ACS grade or higher unless otherwise specified.

Chemical analysis methods used at OWC primarily come from Standard Methods for the Examination of Water and Wastewater, 19th Edition, 1995.

All samples are measured using class A volumetric pipettes or class A volumetric flasks. Reagents are added to samples using repeating syringe-type pipettes.

All glass and plastic ware used in the chemical tests have been precleaned with 10% HCl and then rinsed with distilled water a minimum of 6 times. Between uses, the glass and plastic ware is cleaned as outlined above and then allowed to air dry upside down in the laboratory.

Timeframe

Although the tests can be done in any order, (**exception:** the ammonia test must be done before nitrate test is begun. This is due to contamination problems with the

ammonia blank that will result from the ammonium chloride reagent fumes used in the nitrate test.) The following order is recommended at Old Woman Creek SNP and NERR because it has been found to be efficient both in time and effort. While the samples are being filtered, turbidity and specific conductivity are determined. After each sample is filtered, sub samples for ammonia (50 ml), nitrate (25 ml), and SRP (50 ml), are removed. These sub samples are measured using class A volumetric flasks and or class A volumetric pipettes. Each sub sample is then poured into a numbered erlenmeyer flask.

Ammonia Determination - Spectrophotometer (640nm)

General description: a blue compound, indophenol, is formed by the reaction of ammonia, hypochlorite, and phenol catalyzed by sodium nitroprusside.

Reagents:

- a) Phenol-alcohol Solution: Mix 11.1 ml liquefied phenol ($\geq 89\%$) with 95% v/v ethyl alcohol to a final volume of 100 ml. (Reagent alcohol by VWR)
- b) Sodium Nitroprusside Solution: Dissolve 1 gm $\text{Na}_2\text{Fe}(\text{CN})_5\text{NO}\cdot 2\text{H}_2\text{O}$ in 200 ml distilled water. Store in amber bottle for not more than one month. CAUTION: POISONOUS
- c) Alkaline Citrate Solution: Dissolve 100 gm trisodium citrate and 5 grams Sodium Hydroxide in 500 ml distilled water.
- d) Sodium Hypochlorite Solution: Use a commercial solution of bleach (unscented Chlorox- is the only brand that I have used successfully) with at least 5.25% hypochlorite.
- e) Oxidizing Solution: Mix 4 parts alkaline citrate solution to 1 part sodium hypochlorite solution. This is stable for less than 12 hours.
- f) Stock Ammonium Solution: Dissolve .3819 gm anhydrous NH_4Cl (ammonium chloride)- which has been dried at 100°C in distilled water and make up to 1000 ml. 1.00 ml = 100 microgm N = 122 microgm NH_3 . It is possible to purchase this standard commercially.

Procedure:

- 1) Measure a 50 ml sample (in a 50 ml class A volumetric flask) and pour it into a numbered 125 ml erlenmeyer flask.

- 2) Add all the reagents in a darkened room. Direct light, either natural or fluorescent will change the color of the reaction from blue to green-blue.
- 3) Add 2 ml phenol-alcohol solution (Reagent a) and mix
- 4) Add 2 ml sodium nitroprusside solution (Reagent b) and mix.
- 5) Add 5 ml oxidizing solution (Reagent e) and mix.
- 6) Let stand in dark at room temperature for at least one hour.
- 7) Read color absorption at 640 nm and determine concentration in mg/l from a graph of absorbance vs concentration.

Nitrate- Cadmium Reduction Method – Spectrophotometer (543nm)

General Description: Nitrate is reduced to nitrite in the presence of cadmium. The nitrite is then determined by diazotizing with sulfanilamide and coupling with N-(1-naphthyl)-ethylenediamine dihydrochloride to form a highly colored azo dye that is measured colorimetrically.

Reagents:

- a) Copper-cadmium granules: Wash 25 gm 40- to 60-mesh Cd granules with 6N HCl and rinse with distilled water (at least 3 rinses). Swirl Cd with 100 ml 2% CuSO₄ solution (Reagent f) for 5 minutes or until blue color partially fades. Decant and repeat with 100 ml fresh CuSO₄ until a brown colloidal precipitate develops. Wash Cu-Cd granules copiously (at least 10 times) with distilled water to remove all precipitated Cu.
- b) Color Reagent: To 800 ml distilled water add 100 ml 85% phosphoric Acid and 10 gm. Sulfanilamide. After dissolving sulfanilamide completely, add 1 gm N-(1-naphthyl)-ethylenediamine dihydrochloride. Mix to dissolve and then dilute to 1000 ml with distilled water. Solution is stable for about a month when stored in a dark bottle in the refrigerator.
- c) Ammonium chloride-EDTA Solution: Dissolve 13 gm NH₄Cl and 1.7 gm disodium EDTA in 900 ml distilled water. Adjust pH to 8.5 with conc. NH₄OH and then dilute to 1 liter.
- d) Dilute Ammonium Chloride-EDTA Solution: Dilute 300 ml of Reagent 3 to 500 ml with distilled water.
- e) Hydrochloric Acid, 6N: Mix equal amounts of conc. HCl and distilled water.

- f) Copper Sulfate Solution, 2%: Dissolve 20 gm $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ in 500 ml distilled water and dilute to 1 liter.
- g) Stock Nitrate Solution: Dry potassium nitrate (KNO_3) in an oven at 105°C for 24 hours. Dissolve 0.7218 gm in distilled water and dilute to 1000 ml. Preserve with 2 ml CHCl_3 . 1.00 ml = 100 microgm $\text{NO}_3\text{-N}$. It is possible to purchase this standard commercially.
- h) Standard Nitrate Solution: Dilute 50.0 ml stock nitrate solution to 500 ml with distilled water. 1.00 ml = 10 microgm $\text{NO}_3\text{-N}$.
- i) Stock Nitrite Solution: Dissolve 0.4928 gm KNO_2 in distilled water and dilute to 1000 ml. Preserve with 2 ml CHCl_3 and refrigerate. This is good for 3 months only. 1.000 ml = 100 microgm $\text{NO}_2\text{-N}$. It is possible to purchase this standard commercially.
- j) Standard Nitrite Solution: Dilute 50.0 ml stock nitrite solution to 500 ml with distilled water. 1.00 ml = 10 microgm $\text{NO}_2\text{-N}$.

Procedure:

- 1) Preparation of reduction column: Insert a glass wool plug into bottom of reduction column and fill with distilled water. Add sufficient Cu-Cd granules to make a column of granules approximately 18.5 cm long in reduction column. Insure that water levels remains above granules at all times to prevent entrapment of air. Wash column with 200 ml dilute Ammonium Chloride-EDTA Solution (Reagent d). Activate column by passing through it, at 7 to 10 ml/minute, 100 ml of a solution composed of 25 ml of a 1.0 mg nitrate/liter standard (Reagent g) and 75 ml of the Ammonium Chloride-EDTA Solution (Reagent c). This only has to be done once when the columns are made.
- 2) Adjust pH of sample water to between 5 and 9 with dilute HCl or dilute NaOH.
- 3) To a 25.0 ml sample or a portion diluted to 25.0 ml (measured with a class A 25 ml volumetric flask), add 75 ml Ammonium Chloride-EDTA Solution (Reagent c) and mix. Pour this into column and collect sample at a rate of 7 to 11 ml/ minute. Discard the first 50 ml collected. Use 25 ml of the remainder and treat as a nitrite sample.
- 4) As soon as possible and absolutely no later than 15 minutes after collection, add 1 ml color reagent (Reagent b) and mix.

- 5) Let the samples sit for more than 10 minutes and less than 2 hours before measuring absorbance at 543 nm against a distilled water blank. Determine concentration in mg/l from a calibration curve.

Soluble Reactive Phosphorus- Ascorbic Acid Method- Spectrophotometer (880nm)

General description: Ammonium molybdate and potassium antimonyl tartrate react with orthophosphate in an acid medium to form an antimony-phosphomolybdate complex, which, on reduction with ascorbic acid, yields an intense blue color, which can be measured colorimetrically

Reagents:

- a) 5N sulfuric acid solution: Dilute 70 ml. ACS certified concentrated H_2SO_4 with distilled water to 500 ml.
- b) Potassium antimonyl tartrate solution: Dissolve 1.3715 grams $\text{K}(\text{SbO})\text{C}_4\text{H}_4\text{O}_6 \cdot \frac{1}{2}\text{H}_2\text{O}$ in 500 ml. distilled water. Store in glass-stoppered bottle.
- c) Ammonium molybdate solution: Dissolve 20 grams $(\text{NH}_4)_6\text{Mo}_7\text{O}_{24} \cdot 4\text{H}_2\text{O}$ in 500 ml. distilled water. Store in plastic bottle at 4°C .
- d) Ascorbic acid, 0.1M: Dissolve 1.76 grams ascorbic acid in 100 ml. distilled water. (8.80 gm \rightarrow 500ml.) Solution is stable for about 1 week at 4°C .
- e) Standard phosphate solution: Dissolve 219.5 mg. anhydrous potassium dihydrogen phosphate $[\text{KH}_2\text{PO}_4]$ in distilled water and dilute to 1000 ml. 1.00 ml.=50.0:g $\text{PO}_4\text{-P}$. It is possible to purchase this standard commercially.
- f) Working standard phosphate solution: Dilute 50.0 ml. standard solution to 1000 ml. with distilled water. 1.00 ml.= 2.50:gP

Procedures:

- 1) Measure a 50.0 ml. sample into a 125 ml. erlenmeyer flask.
- 2) Add 1 drop phenolphthalein indicator. If a pink color develops, add 5N H_2SO_4 (reagent a) solution dropwise until color disappears.
 - 1) Add 8.0 ml. combined reagent and mix thoroughly.

Combined reagent is:

50 ml. 5N H_2SO_4 (Reagent a)

- 5 ml. potassium antimonyl tartrate solution (Reagent b)
- 15 ml. ammonium molybdate solution (Reagent c)
- 30 ml. ascorbic acid solution (Reagent d)

Mix after adding each reagent and each reagent must be added in order listed.

- 4) After 10 minutes and before 30 minutes read color absorbance at 880 nm.
- 5) Read concentration from calibration graph of absorbance vs concentration.

Note: In case of highly colored water or turbid water, prepare blank from sample water by adding all reagents but ascorbic acid and antimonyl potassium tartrate. Make a blank from distilled water and treat as a sample. Use blank to zero machine.

Quality Control Program

To insure the accuracy of the chemical data, a program of quality control procedures has been implemented.

Definitions

Blank - a quality control measurement that checks for contamination in reagents or in the distilled water utilized in the chemical test. A sample of distilled water is analyzed as an unknown sample.

Bottle Blank- a quality control measurement that checks for contamination carried over from sample bottle cleaning. Fill sample bottle with distilled water and analyze as an unknown sample.

Field Replicate Samples- separate samples collected sequentially in the field at the same time and place. They are analyzed in the lab as separate samples to assess the precision in field sampling

Laboratory Duplicate Samples- separate sub-samples taken from the same sample bottle in the laboratory to assess the variability in the testing procedures

(Quality Control) Standard Sample- a known concentration of standard is made up and diluted to sample volume using distilled water and analyzed as an unknown sample. Serves as quality control on the sample preparation process and verification of calibration curve

(Matrix) Spike- a known amount of standard is added to a sample to determine percent recovery of the specific chemical being tested. This is used to determine if there are any interferences in the chemical analysis process.

Calibration Curve- a graph of absorption measured by the instrument against known standards. The range of standards should bracket the expected range in concentrations of the unknown samples. Most often produces a straight line.

(Matrix) Spike Sample Preparation- add known standard to sample at a concentration low enough that the spike and standard together will not exceed the range of the calibration curve

Quality Control Procedures at Old Woman Creek

Every time water is collected and chemically analyzed, a minimum of 20% of the samples are replicated in the field and 10% of the samples are duplicated in the laboratory. In the current (2003) sampling program, 10 sites are sampled. At four of the sites, a replicate sample is collected, and back at the laboratory duplicate sub-samples are taken from one of the two replicate samples at each of two sites. Additionally, a blank and a standard are run each time. Spikes are run every time during the monthly sampling, but not during the diurnal sampling. This means that for the 10 sites, a total of 17 samples are analyzed each time. Bottle blanks are run infrequently (2-3 times a year or as needed) to test for possible contamination in the sample bottles. The percent recovery of the spike should range from 95% to 105%. New calibration curves are made when either the spikes or the standards vary from the calibration curve by 15% or more on two consecutive sampling periods.

PREPARATION OF (MATRIX) SPIKE SAMPLES

All Phosphorus Fractions- add 1ml of 5mg PO₄/L standard to sample aliquot. This will produce an increase in concentration of 0.098 mg/L.

Ammonia-Nitrogen- add 1 ml of 5 mg NH₃/L standard to sample aliquot. This will produce an increase in concentration of 0.098 mg/L.

Nitrate-Nitrogen- add 1 ml of 5 mg NO₃/L standard to a 25 ml volumetric flask with the aliquot of sample and dilute to volume with reagent water. This will produce an increase in concentration of 0.200 mg/L.

Storage Procedures

Only under abnormal circumstances are samples ever stored for future analysis. Normally, all chemical analyses (except metals and chlorophyll) are conducted the day of collection.

| Test | Container | Preservative | Holding Time |
|-----------------|---------------|--|----------------|
| Ammonia | P or G | Analyze as soon as possible or add H ₂ SO ₄ to pH<2, refrigerate | 7 days/28 days |
| Nitrate/Nitrite | P or G | Add H ₂ SO ₄ to pH < 2, refrigerate | None 28 days |
| Phosphate | P or G (acid) | Dissolved P filter immediately | 48 hr/NS |
| Silica | P | Refrigerate, do not freeze | 28 days |
| Chlorophyll | P or G | 30 days in dark | 30 days/NS |

Container: P(Plastic) or G (Glass); G(acid) glass acid washed in 1:1 HNO₃

Holding Time: maximum storage recommended/USEPA Rules and regulations 40 CFR parts 100-149, July 1, 1992 (NS= not specified)

ERIE SOIL & WATER CONSERVATION DISTRICT

2900 Columbus Avenue, Sandusky, Ohio 44870

Tel (419) 626-5211, Fax (419) 609 - 9707

Memorandum

To: Tim King, Senior Planner
Erie Regional Planning Commission

From: Eric B. Dodrill, P.E., P.S., District Director

Date: 09/19/2007

Re: TAC Reviews
Huron Green Subdivision No. 5, Huron Township

ESWCD has reviewed the plans received and has provided the following soils information and comments:

Huron Green Subdivision No. 5, Huron Township – Final Plat

| Soil Type | Sewage | Buildings | Streets | Excavation | Bed Rock | Water Table | Frost Action |
|--------------|--------|-----------|----------|------------|----------|-------------|--------------|
| | | | | OSHA Class | | | |
| BkA-Bixler | Severe | Mod./Sev. | Severe | C | >80" | 1.5'-3.0' | High |
| CmA-Colwood | Severe | Severe | Severe | C | >80" | +1.0'-1.0' | High |
| EnA-Elnora | Severe | Mod./Sev. | Moderate | C | >80" | 1.5'-2.0' | Moderate |
| KbA-Kibbie | Severe | Severe | Severe | C | >80" | 1.0'-2.0' | High |
| OhB - Ogontz | Severe | Mod./Sev. | Severe | B/C | >80" | 1.5'-3.0' | High |

- Soils and limitations are as noted above.
- In soils subject to high frost action, local building departments may require additional depth for footings of homes.
- Due to the environmentally sensitive area of Old Woman Creek adjoining this subdivision to the east, particular attention should be given to erosion control practices on the site in construction of streets and homes.

Please contact our office for any further information needed.

cc: File



Appendix C

Data Sheets

Water Quality Sampling Data Sheet

Stream Code: _____ Watershed Name: _____

Monitors _____

Date: ____/____/____ Time: _____ Temp: _____

| Weather in the past 24 hours | Weather now |
|------------------------------|-----------------------------|
| Storm (heavy rain) | Storm (heavy rain) |
| Rain (steady rain) | Rain (steady rain) |
| Showers (intermittent rain) | Showers (intermittent rain) |
| Overcast | Overcast |
| Clear/Sunny | Clear/Sunny |

FIELD USE ONLY

Water Sample Temperature _____ °C

pH reading in buffer 7.0 _____ buffer 10.0 _____

Water sample pH _____

DO _____ drops _____ mg/L

Turbidity _____

LAB USE ONLY

Date Received _____ Date Analyzed _____

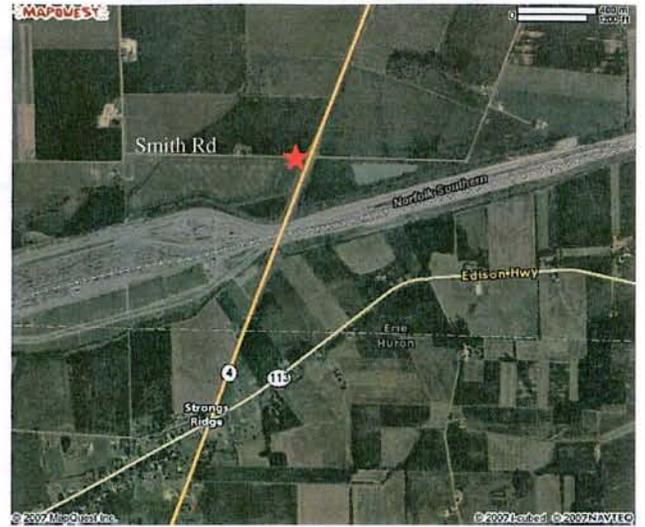
| Sample # | Parameter | Unit |
|----------|--------------|------|
| | SRP | µg/L |
| | NH3 | mg/L |
| | Nitrate | mg/L |
| | Conductivity | mg/L |
| | Turbidity | NTU |

Comments:

Appendix D

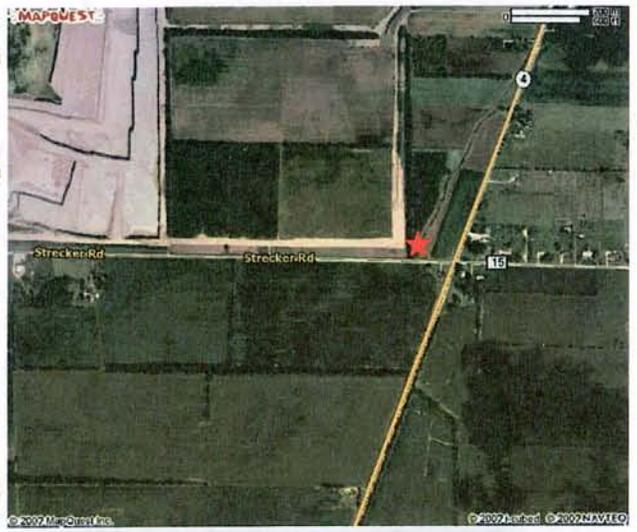
Sampling Site Location Maps and Photos

Pipe Creek Watershed--Wright Ditch

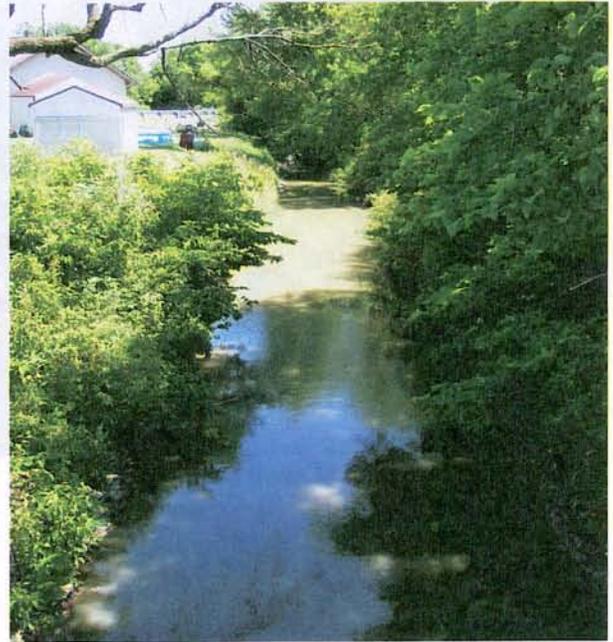


Facing North (Downstream)

PC-10 Pipe Creek Watershed—Pipe Creek (Strecker Rd)

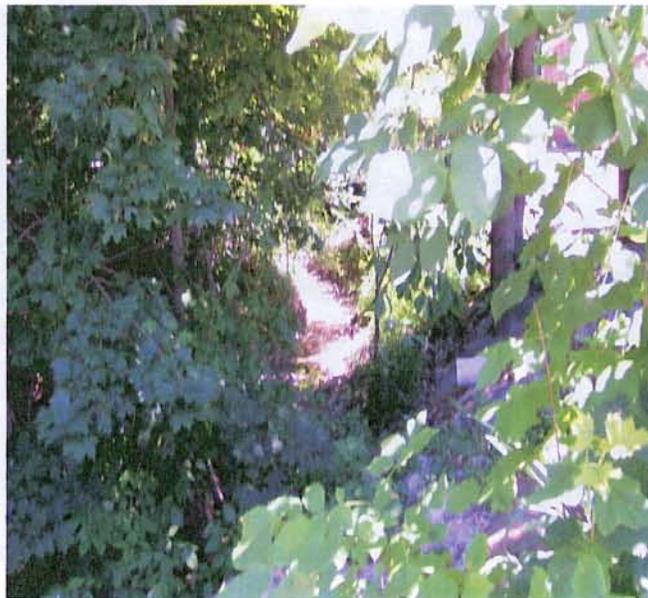


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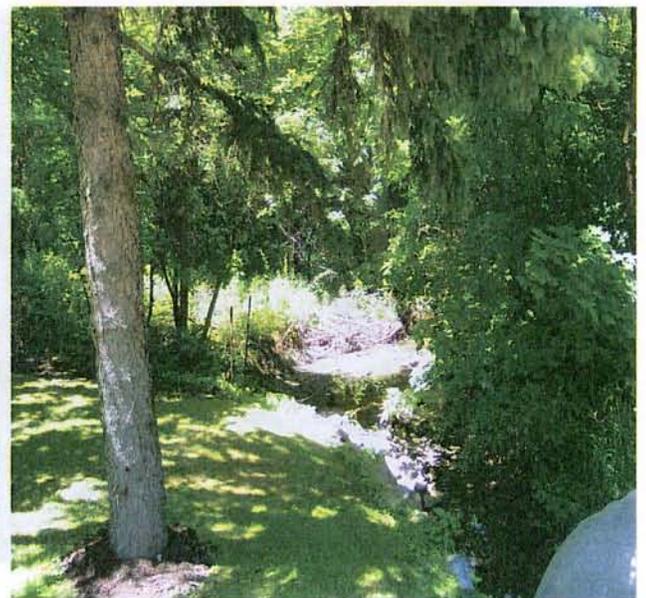


Facing South (Upstream)

PC-20
Pipe Creek Watershed—Pipe Creek (Harris Rd)



Facing South (Upstream)



Facing North (Downstream)

PC-30

Pipe Creek Watershed—Pipe Creek (Patten Tract Rd)



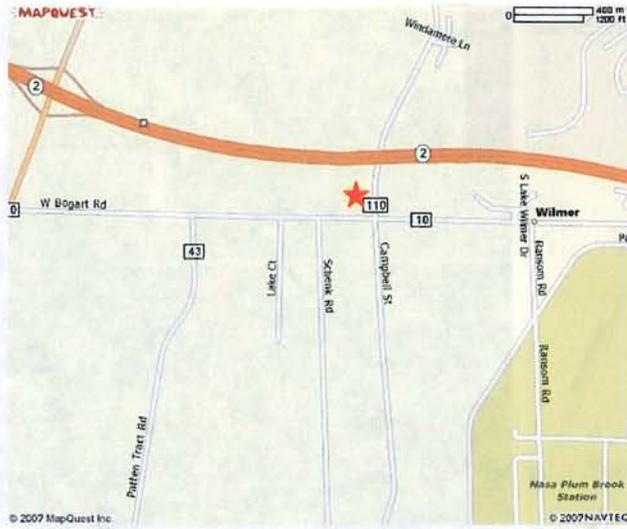
Facing West (Upstream)



Facing East (Downstream)

PC-40

Pipe Creek Watershed—Pipe Creek (Bogart Rd)



Facing North (Downstream)



Facing South (Upstream)

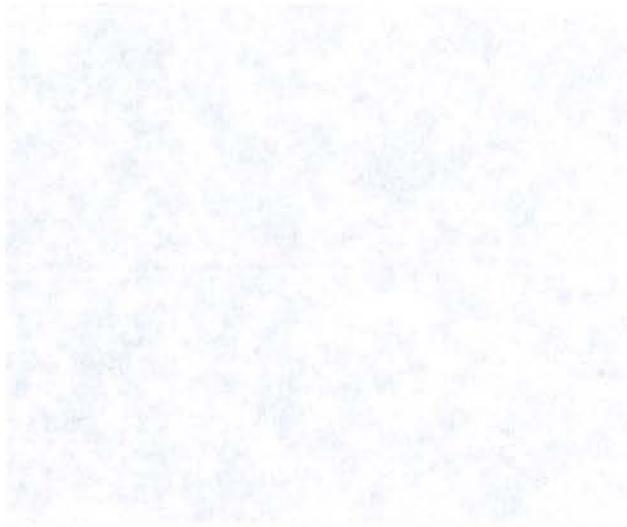
PC-50

Pipe Creek Watershed—Pipe Creek (Campbell St)



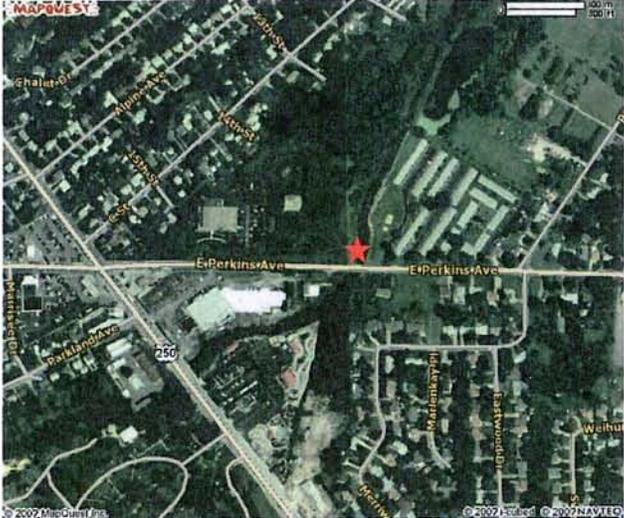
PC-60

Pipe Creek Watershed- Pipe Creek (Columbus Ave)



PC-70

Pipe Creek Watershed—Pipe Creek (Perkins Ave)



Facing North (Downstream)



Facing South (Upstream)

OWC-EB10
Old Woman Creek Watershed—East Branch OWC (Liles Rd)

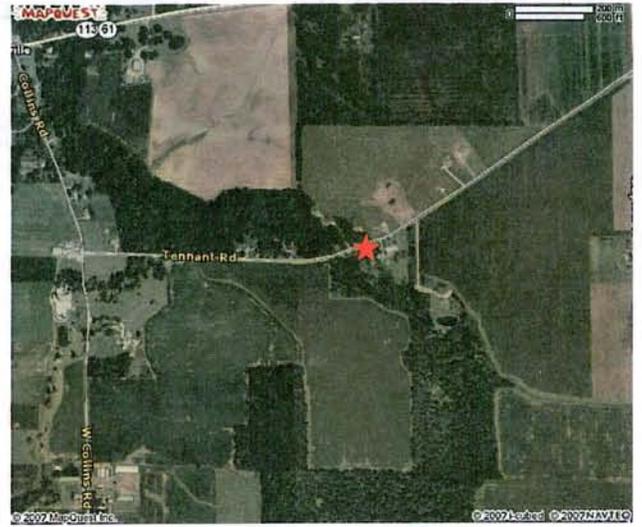
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018V7-0790



OWC-WB10

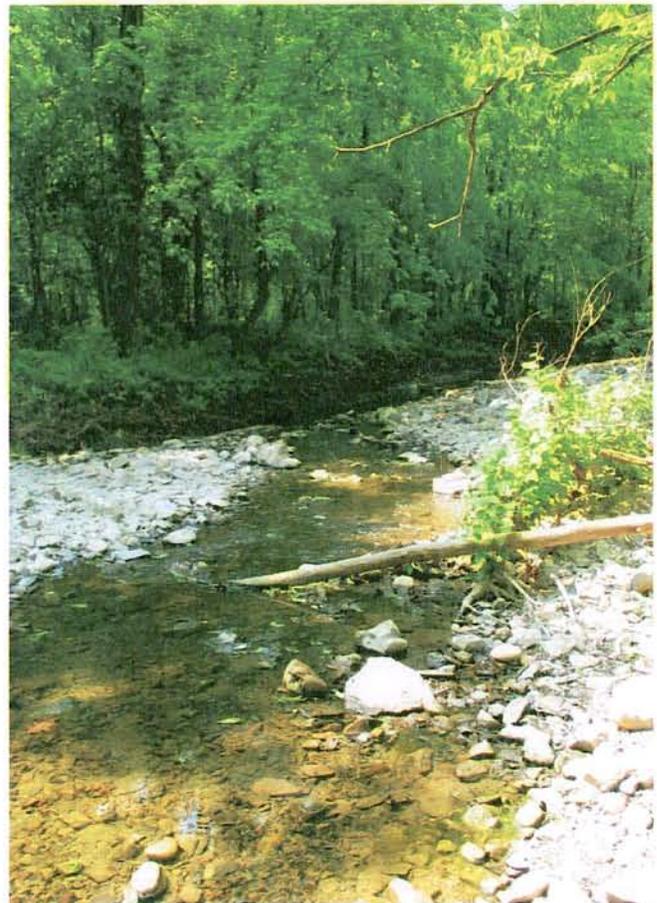
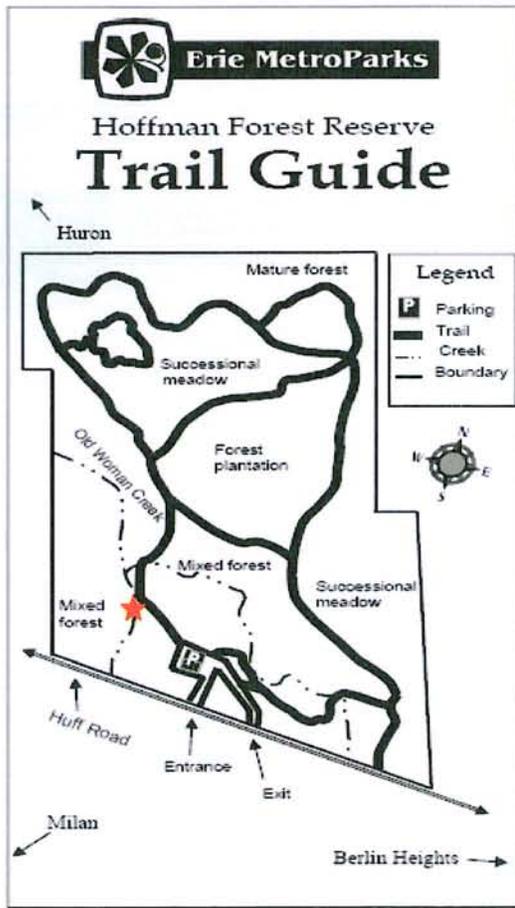
Old Woman Creek Watershed—West Branch OWC (Tenant Rd)

07/13/2010
Old Woman Creek Watershed



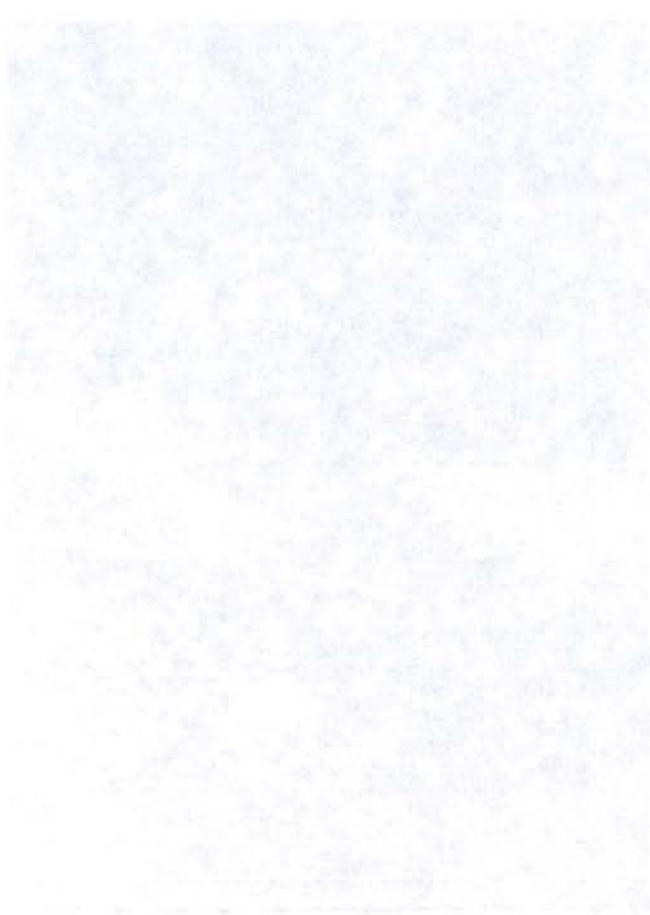
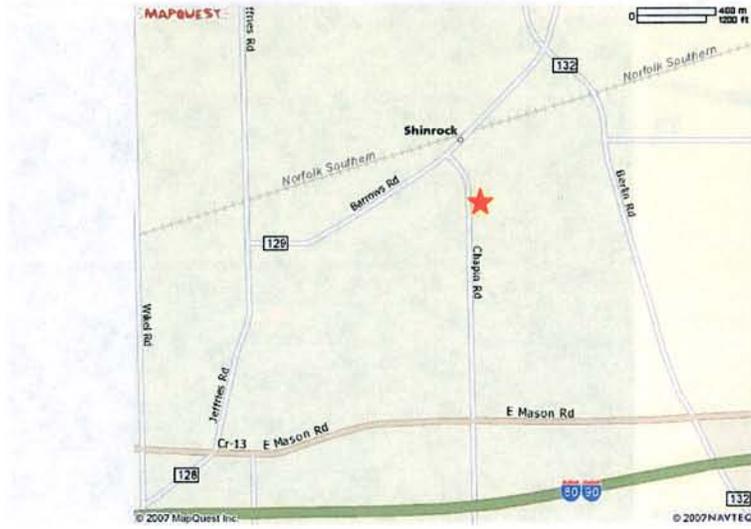
OWC-WB20

Old Woman Creek Watershed—West Branch OWC (Hoffman Woods Preserve)



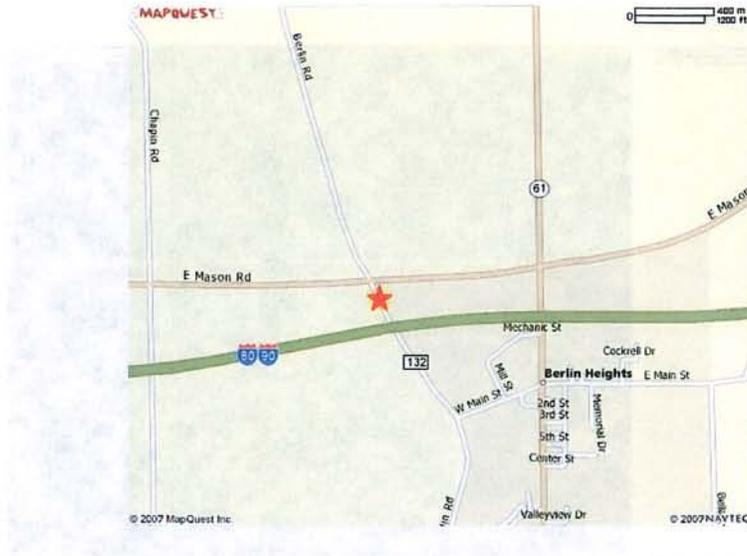
OWC-WB30

Old Woman Creek Watershed—West Branch OWC (N. Chapin Rd near Barrows Rd)



OWC-EB30

Old Woman Creek Watershed—East Branch (Berlin Rd near Turnpike)



OWC-J10

Old Woman Creek Watershed—Junction of east and west branches of OWC (Berlin Rd near Barrows Rd)



Appendix E

Sampling Timeline

Sampling Schedule for Old Woman Creek

Test Parameters

| Site Location | Site Code | January* | February* | March* | April* | May* | June* | July* | August* | September* | October* | November* | December |
|--|--------------|----------|-----------|-------------------------|--|-------------------------|-------------------------|-------------------------|-------------------------|--|-------------------------|-------------------------|----------|
| Liles Road Bridge East Branch OWC | OWC- EB10 | NONE | NONE | Chemical Water Depth | Chemical Water Depth Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | NONE |
| Tenant Rd Bridge West Branch OWC | OWC- WB10 | NONE | NONE | Chemical Water Depth | Chemical Water Depth Biological Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth Biological Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | NONE |
| Hoffman Preserve West Branch OWC | OWC- WB20 | NONE | NONE | Chemical Water Depth | Chemical Water Depth Biological Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth Biological Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | NONE |
| Chapin Road West Branch OWC | OWC- WB30 | NONE | NONE | Chemical Water Depth | Chemical Water Depth Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | NONE |
| Berlin Road Junction of East and West Branch | OWC-J10 | NONE | NONE | Chemical Water Depth | Chemical Water Depth Biological Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth Biological Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | NONE |
| Berlin Road by Ohio Turnpike East Branch OWC | OWC- EB30 | NONE | NONE | Chemical Water Depth | Chemical Water Depth Biological Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth Biological Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | NONE |
| Bellamy Road East Branch OWC | OWC- EB20 | NONE | NONE | Chemical Water Depth | Chemical Water Depth Biological Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth Biological Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | NONE |
| Berlin Road Near Mason Rd East Branch OWC (not approved yet) | OWC- EB40 | NONE | NONE | Chemical Water Depth | Chemical Water Depth Biological Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth Biological Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | NONE |
| Nemire Property East Branch OWC | OWC- EB25 | NONE | NONE | Chemical Water Depth | Chemical Water Depth Biological Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth Biological Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | NONE |

* Chemical and water depth tested the 3rd week of each month, except November which is the 2nd week.

Sampling Schedule for Pipe Creek

Test Parameters

| Site Location | Site Code | January* | February* | March* | April* | May* | June* | July* | August* | September* | October* | November* | December |
|-------------------|-----------|----------|-----------|----------------------|---|----------------------|----------------------|----------------------|----------------------|---|----------------------|----------------------|----------|
| Strecker Road | PC-10 | NONE | NONE | Chemical Water Depth | Chemical Water Depth Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | NONE |
| Harris Road | PC-20 | NONE | NONE | Chemical Water Depth | Chemical Water Depth Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth Biological Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | NONE |
| Patten Tract Road | PC-30 | NONE | NONE | Chemical Water Depth | Chemical Water Depth Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth Biological Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | NONE |
| Bogart Road | PC-40 | NONE | NONE | Chemical Water Depth | Chemical Water Depth Biological Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | NONE |
| Campbell Street | PC-50 | NONE | NONE | Chemical Water Depth | Chemical Water Depth Biological Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth Biological Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | NONE |
| Columbus Avenue | PC-60 | NONE | NONE | Chemical Water Depth | Chemical Water Depth Biological Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth Biological Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | NONE |
| Perkins Avenue | PC-70 | NONE | NONE | Chemical Water Depth | Chemical Water Depth Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth | Chemical Water Depth Biological Erosion Assessment QHEI | Chemical Water Depth | Chemical Water Depth | NONE |

* Chemical and water depth tested the 3rd week of each month, except November which is the 2nd week.

Appendix F

Contact List

Contact List

Watershed Coordinator

Breann Hohman
Erie Soil and Water Conservation District
2900 Columbus Ave Rm 131
Sandusky, OH 44870
419-626-5211
bhohman@erie-county-ohio.net

Monitoring Committee

| Name | Organization/affiliation | Phone | email |
|-------------------------|--|--------------|--|
| Linda Cornell, PhD | BGSU Firelands | 419-433-5560 | lcornel@bgsu.edu |
| Dave Klarer, PhD | OWC Reserve | 419-433-4601 | David.Klarer@dnr.state.oh.us |
| Bob Sennish | Erie County Department of Environmental Services | 419-433-7303 | bsennish@erie-county-ohio.net |
| Charles Herdendorf, PhD | EcoSphere and Assoc. | 440-934-1514 | herdendorf@aol.com |
| Doug Keller | Sandusky Division of Water | 419-627-5815 | Doug.Keller@ci.sandusky.oh.us |
| Barry Riddle | Friends of Pipe Creek Watershed | 419-626-5703 | Rcsltd@sbcglobal.net |

Water Quality Laboratories

Old Woman Creek National Estuarine Research Reserve
2514 East Cleveland Rd.
Huron, OH 44839
Contact: Dr. David Klarer
419-433-4601
David.Klarer@dnr.state.oh.us

City of Sandusky Waste Water Treatment Plant
304 Harrison St.
Sandusky, OH 44870
Contact: Richard Sinwald
419-627-5750
rsinwald@ci.sandusky.oh.us

